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THE STATIC PERFORMANCE OF THE MX902 SATELLITE NAVIGATION EQUIPM--ETC(U)
APR 76 P A KENNEDY, T A JONES

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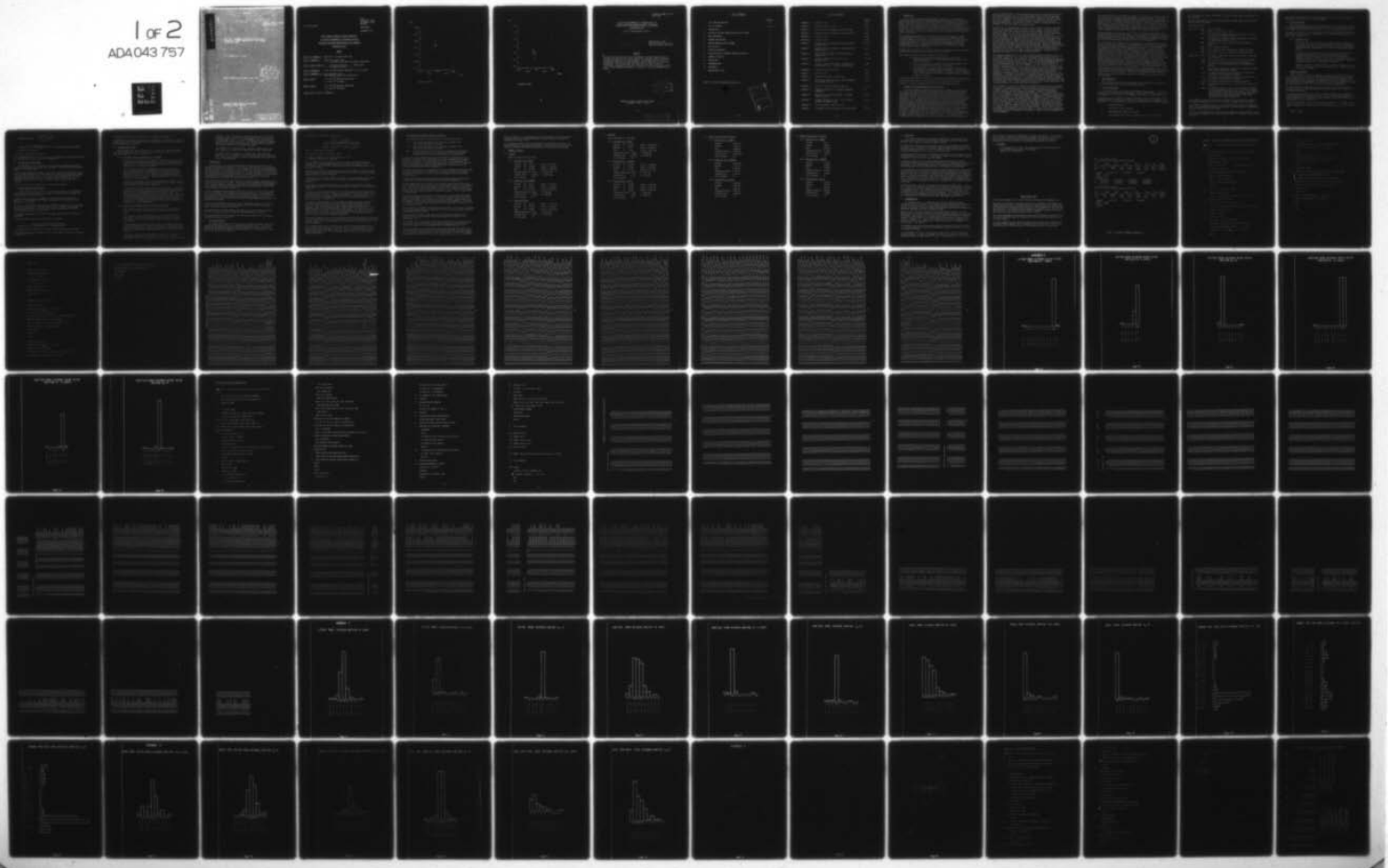

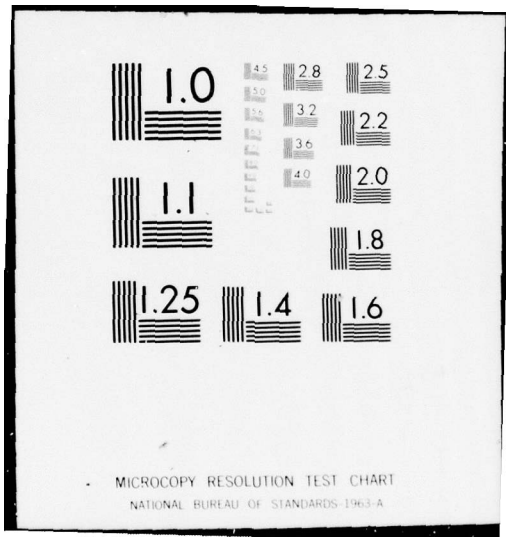
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UNLIMITED

TECHNICAL REPORT TR 76005
(DRIC No BR 48738)

THE STATIC PERFORMANCE OF THE MX902 SATELLITE NAVIGATION EQUIPMENT MANUFACTURED BY THE MAGNAVOX CORPORATION, USA

by

P A C Kennedy and T A Jones

ADMIRALTY SURFACE WEAPONS ESTABLISHMENT
PORTSMOUTH HANTS PO6 4AA

UNLIMITED

ASWE
Portsdown, Cosham
Portsmouth, Hants
PO6 4AA

To all Recipients

XMS5/INFO4.1

September 1976

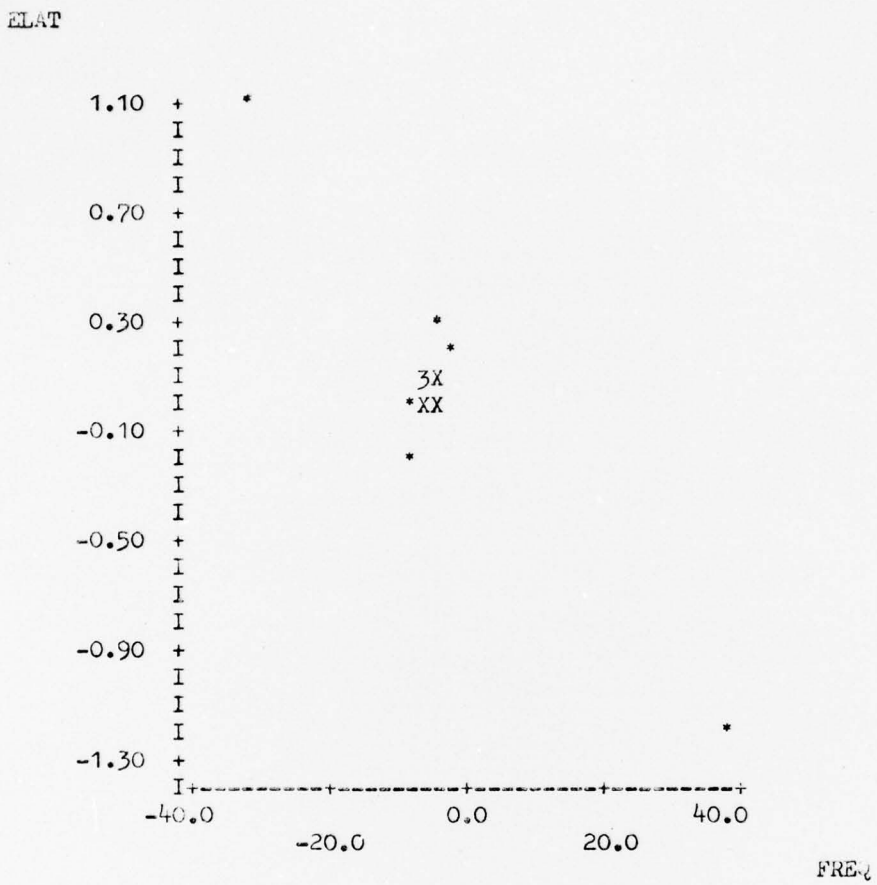
ASWE TECHNICAL REPORT TR 76005 (UNLIMITED)

THE STATIC PERFORMANCE OF THE MX902 SATELLITE NAVIGATION EQUIPMENT MANUFACTURED BY THE MAGNAVOX CORPORATION, USA

ERRATA

PAGE (iii) APPENDIX K	Page Nos K1, K2 should read K1-K4.
PAGE 1, PARAGRAPH 1	Second line should read ".....available to the Admiralty Compass Observatory".
PAGE 4, LINES 26 AND 28	".....are based on the rms....." should read ".....is based on the rms.....".
PAGE 6, PARAGRAPH 5	Sixth line should read "deposited it in a file SATR".
PAGE 7, PARAGRAPH 5.1.1	Last paragraph, Line 2 "distributon" should read "distribution".
PAGE 9, LINE 3	"x is the j^{th} latitude" should read "x_j is the j^{th} latitude".
PAGE 9, LINE 4	"y is the j^{th} latitude" should read "y_j is the j^{th} latitude".

Insert Pages K3 and K4 in Appendix K.



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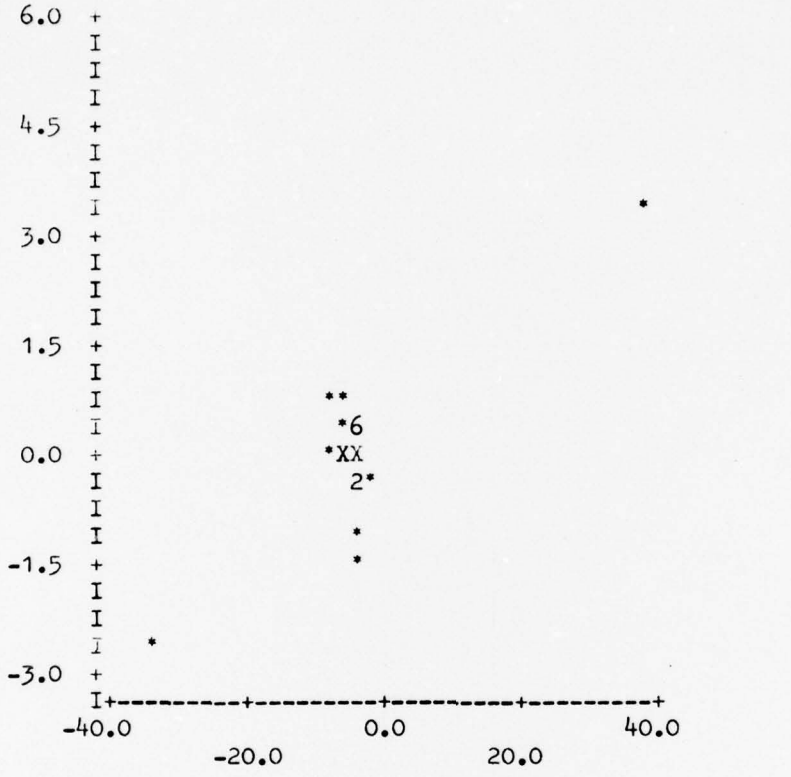

PARTITION: VNFIX

TECHNICAL REPORT TR 76005
April 1976

THE STATIC PERFORMANCE OF THE MX902 SATELLITE NAVIGATION EQUIPMENT MANUFACTURED BY THE MAGNAVOX CORPORATION, USA

by P A C Kennedy and T A Jones

Approved by H T Heal
Head of Navigation Division
Admiralty Compass Observatory

ABSTRACT

The report contains details of an investigation into the accuracy and error patterns obtained with the satellite navigation equipment, MX902, produced by the Magnavox company of the United States. The readings were statistically analysed and found to be in good agreement with the manufacturer's predicted performance. The readings were also studied with a view to finding a relationship between positional error and any of the other calculated variables such as offset frequency and number of iterations: no such relationship was found.

ADMIRALTY SURFACE WEAPONS ESTABLISHMENT
PORTSMOUTH HANTS PO6 4AA

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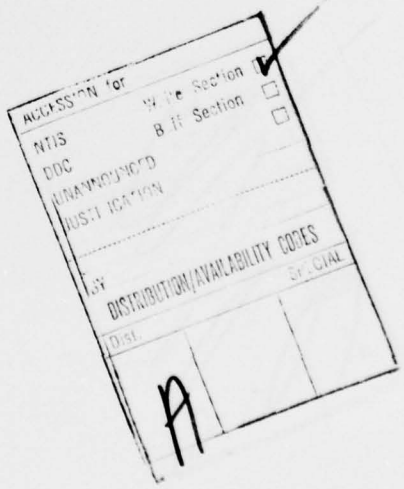
FIGURE 1 SECTION OF ORIGINAL TELETYPE LOG



LIST OF APPENDICES

1. INTRODUCTION

The satellite navigation equipment, MX902, manufactured by the Magnavox Company, was made available at the Admiralty Compass Observatory for a short time before being fitted on board a Royal Naval vessel. This opportunity was taken to assess the static accuracy and error patterns associated with the equipment. No mobile trials were conducted, thus the effect of vehicle motion could not be determined. The fixes obtained were analysed by means of a set of computer programs written in standard Fortran IV, and these were run on Comshare's Rank Xerox RXDS Sigma 9 computer. Programs from Comshare's statistical package (TACTICS) were also used in the analysis.

The assessment presented here is an extension of the work documented in ASWE Technical Report TR-74-19 (Ref 1). Since that report was written more readily accessible computing facilities have been made available, via a contract with the time sharing bureau, and this has necessitated the re-writing of the analysis programs used initially. Communication was via two GPO modem links, one to a 10 character per second teletype and the second to a 30 character per second Tektronic 4010-1 visual display unit.

Comshare have a batch facility on their computer, and using this to run the larger analysis loads overnight gave a considerable saving in cost.

Three types of position fix were available for analysis:-

(a) Position fixes which the system, basing its decision on predetermined parameters, considered adequate to use as a valid "position up-date".

(b) Position fixes which the system, using the same parameter as in (a), considered poor and not to be relied upon.

(c) "Velocity North" fixes which were calculated as a result of a re-estimate of the assumed northerly velocity of the receiving aerial, based on the fix provided in (a) above. Since the receiver used in the assessment was sited in a laboratory, V_N was initially assumed to be zero.

In practice other factors, apart from an actual error in assessing or measuring V_N, can give the same result as an error in V_N. A correction to this value can therefore, in theory, improve the quality of the resulting position fix.

2. OUTLINE OF THE NAVY NAVIGATION SATELLITE SYSTEM

The United States Navy Satellite System, known as TRANSIT, was developed by the US Navy in conjunction with Johns Hopkins University during the early 1960s, and became operational in 1964. At the time of this assessment, the system consisted of six operational satellites in near polar orbit and with an average altitude of 1000 km. Each satellite therefore circumnavigates the earth once every 108 minutes. For an observer positioned at either pole, a satellite would appear over the horizon on average every 18 minutes, as each orbit would pass almost directly overhead. As the observer moves towards the equator, the frequency at which the satellites appear over the horizon decreases as a substantial number of orbits are masked by the earth, and do not rise over the local horizon. At the equator, the average period between observable satellite passes is approximately 90 minutes. As the satellites are launched they are given an orbit which is displaced in longitude to the others, and ideally these angular separations should be equal. As more satellites are introduced to fill in the gaps the symmetry must be upset, but this would occur with time in any case. The altitude of each satellite differs slightly and this will cause them to have differing precession

10. CONCLUSIONS

rates and orbital periods. This means that with time, the orbital separations will slowly change and give rise to a slow beat producing what is known as bunching. The effect of bunching is particularly pronounced at equatorial latitudes, where for certain locations it can cause periods of up to seven hours when no satellite passes are observable. This period can then be followed by a succession of observable passes over a fairly short interval. After a few days this effect will disappear, as the orbits begin to spread out again.

Each satellite is provided with a "Digital Store", a stable oscillator, an S-Band receiver, two low power transmitters and an antenna system. The satellites are also gravity stabilised to ensure that the antenna systems are always directed towards the earth. As the satellites orbit the earth, they continuously transmit two stable frequencies, which are phase modulated with data stored in the satellite's memory. This data describes the actual satellite position at the start of each "Universal Time" two minute period. One complete set of data takes just less than two minutes to transmit, and is known as the "Satellite Message". The transmissions from each satellite are monitored in various parts of the world by ground stations, and these are equipped to determine small variations between the actual orbit and that described by the Satellite Message. Because of the satellite's environment small orbital changes do take place, and a master ground station equipped with a suitable transmitter is able to refresh the variable data in the satellite's digital store by a remote injection procedure. In practice this updating occurs every 12 to 14 hours for each satellite.

The frequency standards used in the satellites are good quality crystal units, and are suitably synthesised to provide both the digital timing waveforms and the transmitter frequencies. The frequencies transmitted by the satellite are nominally 400 MHz minus 32 kHz, and 150 MHz minus 12 kHz. The difference between 400 MHz and the transmitted frequency (minus 32 kHz) is known as the OFF-SET FREQUENCY and is a quantity determined by the receiving equipment. In most receiving sets it is displayed in cycles/minute (32 kHz = 1920000 c/min) and is initially assumed to be unknown. Although the higher transmitted frequency is nominally 399.968 MHz, every satellite will vary slightly as the frequency standard experiences thermal cycling and aging. The local standard in the receiver, against which the satellite frequency is measured, will also drift and therefore must be accounted for in the computation. The aging of the satellite's frequency standard will normally be slow, and therefore given sufficient passes it should be possible to identify frequency bands which move slowly with time. In the MX902-3 systems, the frequency offset is calculated and used to determine the deviation of the receiver local oscillator from its design value. This is then provided as N parts in 10^9, and was evaluated in the following analysis as a possible position error monitor.

If the navigator is to use the information available from the satellite to obtain a position fix, a scheme has to be devised to relate the satellite's position (which is known) to that of the observer. This was achieved by developing special receiving equipment that would measure the change in range of an observable satellite, with respect to a mobile ground-based unit, as the satellite orbits the earth. If the observer remains stationary, the change in range would be due only to the satellite motion. If the observer moves, a component of the range change would be due to his motion over the ground and must be taken into account. The system used in the early receivers was to measure the change in range over each two minute satellite period, which is well defined by timing marks at the beginning of each period. This change in range over the two minute period was measured by comparing the received satellite frequency with a local reference, and determining the number of "doppler" cycles occurring in the measurement period. By this means a direct measurement of the change in range can be made. To obtain a fix three range changes are required in order to determine three unknowns - namely LATITUDE, LONGITUDE and OFF-SET FREQUENCY.

the VN solution could then be determined in a dynamic environment. It is possible that this may be simulated by deliberately applying faulty velocity inputs into a

The disadvantage with the system as described, is that any loss of signal during the two minute period would upset the measurement for the whole period. To overcome this, the current equipments further divide the two minute periods into a number of shorter periods. In the MX902 equipment, the two minute period is divided into five periods: four of 23 seconds and one of 27.6 seconds. These in turn are built up from the basic counting interval used by the receiver of 4.6 seconds. Since these basic counting periods are available to the receiver there is great flexibility in the way they are compiled, and special schemes could easily be devised to limit the effect of wavewash in submarine installations or for an obstructed aerial.

The above scheme works because, within the area of interest, the measured range changes are peculiar to only one location. By successive iterations from an assumed position the actual position may be resolved. One measure of the quality of the fix are the residuals, which are the rms values of the differences between the measured and finally calculated range differences used in the fix computation.

One novel feature of the MX902 series of equipments, is a program technique known as the "Velocity North" solution. The requirement to know the vehicle's speed over the ground has already been briefly discussed, and any error in the assessment of this quantity will give rise to erroneous position fixes. The position error patterns are quite systematic with velocity errors, but the problem is that the actual velocity errors are not known. If they were, correction to the velocity inputs could be made to prevent the position errors arising in the first place. Typically an error of 1 knot in the Velocity North component of vehicle motion will give rise to a position error in longitude of 0.2 nm, and an error of 1 knot in the Westerly Velocity will give an error of 0.05 nm in latitude. To overcome this problem, Magnavox have devised a technique of using the normal position fix to assess the actual vehicle speed, and then use this to recompute a further position fix. All the parameters that could give rise to Velocity North type errors, are assumed to be due to an error in the V_N estimate. It was postulated that this may cause problems, and the assessment presented in this report addresses this. The "trial receiver" was stationary throughout the data gathering periods, and therefore no V_N errors should have occurred. Any non-velocity-generated errors treated as velocity errors would therefore be assumed to be systematic, and they may well in fact be random.

3. DATA PREPARATION

The following section details the methods used to convert the available data into a form suitable for use by the statistical programs.

3.1 Initial Preparation

The initial data is in the form of a teletype log, see Figure 1. Each fix record consists of the title of the program: "400 Fix ACO-SY-75030" in the case of a standard fix, and "400 VN Fix ACO-SY-75030" in the case of a Velocity North fix.

The second line is a record of the Doppler periods, each two minute Doppler period being split into five sub-periods, four of 23 seconds and one of 28 seconds. Each character in a line represents one sub-period, and they have the following meanings:-

1	Good data received.
0	Very bad or no data received.
?	Data taken when satellite below $7\frac{1}{2}^{o}$.
=	Data had some errors but the computer was able to edit them out.

The line below this contains two arrows (↑↑) which indicate where the centre of the pass occurred.

The next two lines list the various measured and calculated quantities, with their values on the line beneath.

The quantities are:-

First line -

- DAY - Julian day number.
- TIME - Hours, minutes, seconds in GMT.
- LAT - Fix Latitude in degrees, minutes and decimals of a minute followed by the direction, N or S.
- LON - Fix Longitude in degrees, minutes and decimals of a minute, followed by the direction, E or W.
- ANT - The height of the aerial above the reference geoid in metres.
- HDG - Ship's heading in degrees.
- SPD - Ship's speed in knots (usually speed through the water).
- NVEL - Calculated Velocity in a Northerly direction in knots.

Second line -

- ITER - The number of iterations taken by the program to calculate the resulting fix.
- ELEV - The maximum elevation of the satellite above the horizon.
- GEOM - The direction of the satellite, eg N-W indicates the satellite is travelling North, and is to the West of the observer.
- SAT - The satellite identifier. There are six satellites, 30120, 30130, 30140, 30180, 30190, 30200.
- S-LA - The standard deviation of the latitude in minutes of arc are based on the rms doppler residuals.
- S-LO - The standard deviation of the longitude in minutes of arc are based on the rms doppler residuals.
- S-VN - The standard deviation of the Northerly Velocity.
- RMS - Calculated rms error of fix, in nautical miles, using S-LA and S-LO.
- FREQ - The offset frequency of the local oscillator with respect to its design value in parts in 10^9. This should be small and not change by more than 3 units per day. If a satellite pass results in a value which differs by more than a few counts from the results of other passes, then it was considered to be a poor position fix.

The S-UPDATE line gives the differences in nautical miles between the present fix and the dead reckoned position fix, in latitude, longitude and radial distance.

The C-WHDG and C-WSPD represent the calculated water heading and calculated water speed. The calculations are based on the drift, calculated from the S-UPDATE data, divided by the time since last update.

The last line indicates whether the system considered the fix sufficiently accurate to be used as an update, this shown by the word UPDATE, or N-UPDATE in the case of a poor fix.

The data was punched onto paper tape which was then fed into the bureau computer's store, here it was stored in a file called SATDAT.

3.2 Wild Point Editing

Since the data was produced while the receiver was at a fixed position, ideally the latitude and longitude should have been invariant, but to prevent the analysis of the data being corrupted by "gross errors", it was considered necessary to edit.

There were two stages to the editing procedure, the first performed by the analysing computer and the second by the investigator. This second editing takes place at a later stage, see Section 4.1.

3.2.1 Computer Editing

The program SAT 1 read the records from SATDAT, and transferred part of this to the file SATD. It also checked that the number of degrees of latitude and longitude were correct (this was justified as the latitude and longitude were approximately in the centre of two integer degree points).

In the editing procedure two fixes were edited out, these being the standard and Velocity North fix from the same satellite pass. Examination of this fix showed that the local oscillator offset frequency in both cases was very large, -3187.6 and -3044.6 respectively, which indicates that the receivers had not fully warmed up. This had caused very large errors in latitude and longitude.

Appendix A contains a listing of SAT 1, the print out from a run of SAT 1 and a print out of the two erroneous records. Appendix B contains a listing of file SATD.

4. PRIMARY CALCULATIONS

Using the TACTICS statistical programs, the data on file SATD was first split into three partitions. The first contains those ordinary fixes that the computer used to update the current position, and was called partition FIX.UPDATE. The second contains ordinary fixes that the computer did not use to update position, and was called partition FIX.NOUPDATE. The third contains all Velocity North fixes and was called partition VNFIX. All partitions were treated independantly.

The true latitude and longitude of the receiver site were 51^{o} 29.45' North and 0^{o} 33.583' West, these were determined by an accurate survey and are based on the UK Ordnance Survey geoid.

The latitude and longitude errors from the true position were first determined. These were then investigated, by partition, using the TACTICS command ANALYZE. This gives a print out of:- the number of cases examined, the minimum, maximum, mean, standard deviation and standard error.

The following formulae are used to calculate these figures. In all cases n is the number of readings, $\bar{x}$ is the mean value of the readings and x_j is the j^{th} reading.

$$\text{Mean } \bar{x} = \frac{1}{n} \sum_{j=1}^{n} x_j$$

Standard Deviation $\sigma = \sqrt{\frac{1}{n-1}\sum_{j=1}^{n}(x_j-\bar{x})^2}$

Standard Error = $\frac{\text{Standard Deviation}}{\sqrt{n}}$, this is sometimes called the Standard Deviation of the means.

The results can be found in Section 9.

The HISTOGRAM command was then used to produce histograms of latitude and longitude for each partition. These can be seen in Appendix C.

4.1 Editing by the Investigator

On examination of the histograms, it was apparent that there were several fixes which had errors much larger than the others. There were four such records, Numbers 17, 18, 229 and 284.

The full record of each was checked, and in each of the first three cases it was found that the difference in offset frequency from the previous record was greater than three, which causes errors. In the last case it was noted that the ship's speed had been increased from zero, the correct figure, to 20 knots. This error was attributed to this large, erroneous, change in speed, and the fix rejected.

These four records were excluded from all further calculations.

5. FURTHER ANALYSIS AND HISTOGRAMS

From the results obtained from this and previous analysis, it was decided to investigate the records further in an attempt to determine possible trends and relationships in the error patterns.

To facilitate this analysis a program, SAT 2, was written and is shown in Appendix D. This read data from SATDAT, transformed it to a useable form and deposited in a file SATR.

The error in latitude and longitude was calculated, in nautical miles. This used the fact that one minute of latitude equals, for a first order, one nautical mile and that longitude error in nautical miles equals longitude error in minutes multiplied by the cosine of the latitude.

The number of good doppler counts before and after the centre of pass were also calculated.

Finally the radial error was calculated from the equation:-

Radial error = $\sqrt{(\text{latitude error})^2 + (\text{longitude error})^2}$

and the bearing of the satellite fix position from true North was calculated.

The TACTICS package was now brought into use and the data partitioned, as described in Section 4.

The data was printed out by partition and is contained in Appendix E.

An analysis and histogram, by partition, was produced for latitude error, longitude error, radial error and bearing from North. The analysis can be found in Section 9 and the histograms in Appendix F.

5.1 Histogram Distributors

The histograms were then investigated, and in some cases further histograms with smaller ranges were plotted so that their shape could be seen more clearly. These histograms can be found in Appendix G.

5.1.1 Latitude Error and Longitude Error Histograms

The latitude and longitude histograms for the updated fixes (partition FIX.UPDATE) show clearly defined peaks and the points distributed in a normal manner. The mean was not zero thus showing there is an offset from the actual latitude and longitude.

The latitude and longitude histograms for the fixes not used for a position update (partition FIX.NOUPDATE), and Velocity North fixes (partition VNFIX), cover a wider range due to the greater scatter of the points. Because of this the majority of the points tend to be within three or four intervals. Again the means were not at zero, thus indicating a position offset.

In order to investigate further, more histograms were plotted. These were centred on the mean and had a range of about one standard deviation. These histograms can be found in Appendix G.

To confirm that the distributions were Gaussian (normal), a normalised Gaussian distributor was calculated from the measured mean and standard distribution. A Chi-squared test was then carried out between the measured cumulative distribution and the calculated values. The Chi-squared figure was always sufficiently small to be able to say that the measured distribution was part of the calculated distribution. In all cases points beyond three standard deviations from the mean were ignored. This is statistically valid as these points are probably due to systematic and not random errors.

5.1.2 Radial Error and Bearing from True Position Histograms

With a perfect radial error distribution, affected only by random noise, a half normal distribution would be expected, with a peak at zero.

The histogram for the updated fixes shows a half normal distribution but the peak is offset to a distance of about 0.035 nautical miles. This offset was to be expected from the mean latitude and longitude calculations.

The histograms for the two other partitions, the NO-UPDATE fixes and the Velocity North fixes, shows a large peak and a large range, being 5 nm and 4 nm respectively. When the large peak was plotted in greater detail a histogram of the same shape as that for the updated fixes was produced.

The single frequency satellite navigation system is less precise in its longitude fixes than its latitude fixes, and will give a wider distribution of fixes in the East-West direction than in the North-South

direction. Thus a histogram of bearing from North would be expected to show two peaks, one at 90^{o} (corresponding to East) and one at 270^{o} (corresponding to West). It must be remembered that on the bearing histogram 360^{o} is equivalent to 0^{o}. The bearing histogram for updated fixes did not conform to that predicted. Only one peak was apparent and this was centred at a bearing of about 280^{o}.

The N-UPDATE fix histogram was more scattered, probably due to the small number of cases used, but a peak could be seen at about 300^{o}.

The Velocity North histogram, on the other hand, showed the same distribution as the updated fixes, with only one peak centred at about 290^{o}. This clearly called for further investigation, and is dealt with in the following section.

6. SCATTER PLOTS

A scatter plot is a plot of latitude against longitude; from this one can observe the dispersion of the fixes. Plots for all three partitions were produced, and these can be found in Appendix H; this appendix also contains the program output for each partition. A plot routine, SAT 3, was written to produce the scatter plots. This program requires the operator to type in: a title, the outer limit of the plot, the file holding the input data and the file to which the plot data is to be written. During operation the program types out any position fixes which are exactly coincident and any fixes which are outside the outer limit.

The program used subroutines from Comshare's CIL Plotter package, and produced data suitable for driving a CIL plotter. Since the Admiralty Compass Observatory does not have a plotter capable of generating the scatter plots, paper tapes were generated by the Comshare computer and taken to ASWE where a suitable device is held. The plotting routine is listed in Appendix I.

The plot of updated fixes demonstrated that most of them lie to the North and West of the true position, thus accounting for the bearing of 280^{o}. It could then be seen that the dispersion was greater in the East-West direction than in the North-South direction. Thus the explanation of the bearing histogram is that the displacement of the mean from the true position is sufficiently great to conceal the East-West distribution.

The plot for the N-UPDATE fixes shows a more scattered distribution, but there is still a noticeable bias to the West and North, and the East-West distribution is larger than the North-South distribution.

The Velocity North partition scatter plot shows very clearly the North and West bias with a larger East-West distribution than North-South distribution.

Thus the North and West bias shown on the scatter plots explains why the bearing histograms had peaks at about 290^{o}.

7. STATISTICAL ANALYSIS

The normal distribution of the latitude and longitude histograms, would tend to indicate that errors are due to a random (white noise) effect. To test the hypothesis, the TACTICS package was used to correlate all the variables. Three correlation matrices were produced, one being generated for each partition. These matrices are contained in Appendix J.

The correlation coefficient is equal to:-

$$\frac{n\sum_{j=1}^{n} x_j y_j - \sum_{j=1}^{n} x_j \cdot \sum_{j=1}^{n} y_j}{\left[n\sum_{j=1}^{n} x_j^2 - \left(\sum_{j=1}^{n} x_j\right)2\right]^{\frac{1}{2}} \left[n\sum_{j=1}^{n} y_j^2 - \left(\sum_{j=1}^{n} y_j\right)2\right]^{\frac{1}{2}}}$$

where n is the number of readings

x is the j^{th} latitude or longitude reading

y is the j^{th} parameter of the value against which the correlation coefficient is required.

For the UPDATE fixes, the highest correlation factor occurred when comparing Latitude errors against offset frequency. At 0.3207, this figure is not sufficiently high to establish any significant correlation between Latitude error and offset frequency.

The other two partitions show significant correlation between Latitude error and offset frequency, for the Velocity North fixes there is also a correlation between Longitude error and offset frequency.

To investigate this further, graphs of latitude error and longitude error against offset frequency, for the particular partitions in question, were produced, (Appendix K).

In all cases it can be seen that there is a cluster of points around the most common offset frequencies, but that any large offset frequency has a corresponding large error.

Thus the correlation does not denote a linear relationship between latitude error or longitude error and offset frequency, but simply confirms the fact that a large offset frequency will produce a large positional error. Having explained this there are no other significant correlations, thus the postulated hypothesis must have a high degree of probability.

To verify this beyond doubt, the linear stepwise regression program contained in the TACTICS package was used on both latitude errors and longitude errors by partition. They were regressed onto DAY, Minutes (MIN), Iterations (ITER), Elevation (ELEV), Offset frequency (FREQ), number of doppler counts before centre (NOBC) and number of doppler counts after centre (NOAC). The term R-Square is a measure of fit: the closer it is to unity the better the fit. This is defined as the proportion of the total variation about the mean of the dependant variable, which is accounted for by the regression equation.

The results, Appendix L, show that only the Velocity North fixes have any significant value of R-squared, and that for longitude the error was only marginally significant. For both latitude error and longitude error, the major part of the fit was due to the offset frequency.

It is therefore possible that there is some linear relationship between Velocity North position errors and offset frequency. It is still not possible to say that there is a definite relationship as over 10% of the distribution about the mean remained unaccounted for. This is not good enough to make a definite statement about a relationship.

8. INVESTIGATION OF EQUIPMENT PRODUCED STATISTICS

This equipment produces three positional fix accuracy indicators:-

S-LA - the standard deviation of the latitude in minutes of arc based on the rms Doppler residuals.

S-LO - the standard deviation of the longitude in minutes of arc based on the rms Doppler residuals.

RMS - the calculated rms error of the fix, in nautical miles using the previous two quantities and the quantity S-VN (the calculated standard deviation of the Velocity North) where applicable.

In doing this, the equipment manufacturers have made the assumption that the majority of the latitude and longitude errors can be attributed to the Doppler calculation residuals. In order to test if this was a valid assumption, the values of the measured latitude and longitude errors, in minutes of arc, and the absolute values were calculated and then correlated, by partition, with the respective three equipment values (Appendix M).

For updated fixes, there is no significant correlation between the measured values and those calculated by the equipment. For the two other partitions a fairly high degree of correlation is shown between the measured values and equipment produced figures.

To investigate further, graphs were produced of measured absolute latitude and longitude errors against the equipment calculated values (Appendix N).

On investigation each graph showed a similar pattern consisting of most of the points clustered near the origin but with a small number of points a great distance away. The conclusion that may be drawn from this, is that very large residuals, which result in the equipment producing a large value of S-LAT and S-LON, do give bad fixes and thus large latitude and longitude fix errors. This is a fact which is already known.

It was now necessary to investigate if there was any linear relationship between measured and equipment produced values. To do this a further TACTICS facility, regression, was used. This allows a multivariate, stepwise, linear regression to be performed on any variable, the resulting outputs are in Appendix O. R-squared is a measure of how well the measured points fit the equation, the closer it is to unity the better the fit.

For the update fix latitude and longitude errors, R-square is very low. This agrees with the correlation figures and indicates no linear relationship between measured and equipment produced figures.

The other partitions show a significant value for R-squared, except for the longitude errors in the N-UPDATE fixes where R-square has a medium to low significance of 0.37.

For N-UPDATE fixes, the measured latitude and longitude errors are equal to some constant plus about three times the corresponding equipment calculated values. Thus for this type of fix, the equipment tends to underestimate the error.

For Velocity North fixes, the measured latitude and longitude errors are equal to some constant plus about one third the corresponding equipment calculated values. In this case the equipment appears to have over estimated. In truth the equipment has assumed that the Northerly velocity is unknown, and has put it as a variable

in its calculations. Thus although the set was stationary, it has calculated a Northerly velocity and therefore produced a larger calculated latitude and longitude error (S-LA, S-LO).

It is therefore apparent, that the equipment calculated "error indicators" are markedly different from the measured figures. As an indication of fix quality, they could therefore be quite misleading and of little use to the navigator.

9. SUMMARY OF RESULTS

9.1 Latitude

Actual Latitude 51^{o} 29.45' North.

9.1.1 Partition Fix: UPDATE

Minimum	51^{o}	29.39'	(Error = -0.06 nm)
Maximum	51^{o}	29.586'	(Error = 0.136 nm)
Mean	51^{o}	29.476'	(Error = 0.0250 nm)
Standard Deviation		0.0211'	(= 0.0211 nm)
Standard Error		0.00178'	(= 0.00178 nm)
No of readings		140	

9.1.2 Partition Fix: N-UPDATE

Minimum	51^{o}	29.31'	(Error = -0.14 nm)
Maximum	51^{o}	29.582'	(Error = 1.132 nm)
Mean	51^{o}	29.519'	(Error = 0.0687 nm)
Standard Deviation		0.204'	(= 0.204 nm)
Standard Error		0.0286'	(= 0.0286 nm)
No of readings		51	

9.1.3 Partition VN Fix

Minimum	51^{o}	28.238'	(Error = -1.212 nm)
Maximum	51^{o}	30.502'	(Error = 1.052 nm)
Mean	51^{o}	29.485'	(Error = 0.0355 nm)
Standard Deviation		0.151'	(= 0.151 nm)
Standard Error		0.0137'	(= 0.0137 nm)
No of readings		121	

9.2 Longitude

Actual Longitude 0^{o} 33.583' West.

9.2.1 Partition Fix: UPDATE

Minimum	0^{o}	33.474'	(Error = -0.0679 nm)
Maximum	0^{o}	34.01'	(Error = 0.266 nm)
Mean	0^{o}	33.701'	(Error = 0.0735 nm)
Standard Deviation		0.0874'	(= 0.0544 nm)
Standard Error		0.00738'	(= 0.0046 nm)
No of readings		140	

9.2.2 Partition Fix: N-UPDATE

Minimum	0^{o}	30.372'	(Error = -1.999 nm)
Maximum	0^{o}	41.078'	(Error = 4.642 nm)
Mean	0^{o}	33.761'	(Error = 0.111 nm)
Standard Deviation		1.239'	(= 0.771 nm)
Standard Error		0.173'	(= 0.108 nm)
No of readings		51	

9.2.3 Partition Fix: VN Fix

Minimum	0^{o}	29.286'	(Error = -2.676 nm)
Maximum	0^{o}	39.162'	(Error = 3.474 nm)
Mean	0^{o}	33.697'	(Error = 0.071 nm)
Standard Deviation		0.752'	(= 0.468 nm)
Standard Error		0.064'	(= 0.0426 nm)
No of readings		121	

9.3 Radial Error from True Position

9.3.1 Partition Fix: UPDATE

Minimum	0.0207 nm
Maximum	0.297 nm
Mean	0.0846 nm
Standard Deviation	0.0479 nm
Standard Error	0.00405 nm
No of readings	140

9.3.2 Partition Fix: N-UPDATE

Minimum	0.0218 nm
Maximum	4.718 nm
Mean	0.346 nm
Standard Deviation	0.729 nm
Standard Error	0.102 nm
No of readings	51

9.3.3 Partition Fix: VN FIX

Minimum	0.0282 nm
Maximum	3.679 nm
Mean	0.201 nm
Standard Deviation	0.456 nm
Standard Error	0.0414 nm
No of readings	121

9.4 Angular Displacement from North

9.4.1 Partition Fix: UPDATE

Minimum	0.0^{o}
Maximum	348.72^{o}
Mean	276.67^{o}
Standard Deviation	65.879^{o}
Standard Error	5.5678^{o}
No of readings	140

9.4.2 Partition Fix: N-UPDATE

Minimum	10.081^{o}
Maximum	350.92^{o}
Mean	236.72^{o}
Standard Deviation	97.607^{o}
Standard Error	13.668^{o}
No of readings	51

9.4.3 Partition Fix: VN FIX

Minimum	1.6971^{o}
Maximum	352.02^{o}
Mean	264.13^{o}
Standard Deviation	86.99^{o}
Standard Error	7.9082^{o}
No of readings	121

be equal. As more satellites are introduced to fill in the gaps the symmetry must be upset, but this would occur with time in any case. The altitude of each satellite differs slightly and this will cause them to have differing precession

10. CONCLUSIONS

The system performed well giving good accurate fixes. The position errors were due to both an offset error, which was to the North and West of the actual position, and a normally distributed random variation.

The offset error could be due to the actual position not being known sufficiently accurately, or a difference in the geoidal reference system used by the satellite navigator computer program and the British Ordnance Survey reference system. This is being investigated with the Ordnance Survey Authorities.

For good fixes in both latitude and longitude, the offset error is greater than the standard deviation of the noise. A significant increase in accuracy could therefore be obtained if the offset error could be removed.

A statistical analysis of the results demonstrated that there was no linear correlation between the accuracy of the fix and any of the variables printed out by the system. It was observed that large shifts in some of the variables, such as offset frequency, did produce large errors; an effect which was postulated.

The investigation of the equipments estimate of standard deviation for latitude and longitude, based on the position calculation residuals, showed that in the case of good fixes there was no relationship between these figures and the actual measured figures. There was some degree of correlation for bad (N-UPDATE) fixes and Velocity North fixes, and this varied from about three times too large for Velocity North fixes to three times too small for bad fixes. In consequence a navigator could put little reliance on the equipment produced fix parameters and as such they are very misleading.

The Velocity North fixes were on the whole worse than the standard fixes. This would indicate that adding Velocity North as an unknown to the program, has resulted in an increase rather than a reduction, in the calculated position error. It must be remembered that all results were obtained with the receiver stationary, and therefore no vehicular motion effects were introduced. The purpose of the VN fix is to improve the VN assessment of the vehicle motion, and in a dynamic situation where there may well be SPEED LOG errors some improvement may well exist.

11. RECOMMENDATIONS

The equipment produced standard deviation and rms figures are largely erroneous, and thus misleading. These figures should be removed from the printout. They could be replaced by a fix quality figure based on the residuals of the computer calculation. Navigators would then learn from experience the magnitude of the errors associated with each fix quality figure.

Magnavox should thoroughly investigate the Velocity North program. Since the manufacturer has not released details of the VN program, no meaningful suggestions can be made. Nevertheless, if the program does treat Velocity North as a complete unknown, taking no account of the input speed (either automatic or manual), this could be a problem area. Before final publication of this report Magnavox has studied its contents and a Manufacturer's Note concerning this recommendation has been included. (See Page 16).

The equipment supplier should be asked to provide the geoidal co-ordinate system used in the computations. With this information it would be possible to calculate the theoretical offsets.

Twelve equipments are now in service with the Royal Navy, and at-sea experience is now being gained. In order to supplement the static assessment, the in-service operators should keep good records of fixes for subsequent analysis. The value of

the VN solution could then be determined in a dynamic environment. It is possible that this may be simulated by deliberately applying faulty velocity inputs into a static receiver, and this should be further studied. Equipment availability prevented any further extension of the assessment described in this report.

12. REFERENCES

1. P A C Kennedy and T A Jones. "Performance of Satellite Positioning Corp Type SCS-100 Satellite Navigation Equipment" ASWE TR-74-19 (UNLIMITED).

MANUFACTURER'S NOTE

The following comments on this report have been received from the Magnavox Co:-

The report is considered to be good, giving a fair assessment of the operation of Magnavox systems software. Magnavox would like to point out that the comment made in the report as to the Velocity North portion of the programme could have been more meaningful had the system been tested by entering false velocities in the north or south direction. This would cause the software to attempt to resolve true velocity north and give a more accurate position fix as a result.

The V North programme has been updated to take care of problems associated with the velocity solution and steps are being taken to retrofit existing systems with the corrected software.

The report comments on the sigma values printed out after the fix calculation are being considered by Magnavox but the company points out that these values are not provided to give a firm indication of fix accuracy but only as a rough guide.

= Data had some errors but the computer was able to edit them out.


```
400   FIX ACO-SY-75030
0000111111111111111111111111111111111111100
                        ^^
DAY        TIME       LAT         LON         ANT        HDG     SPD     NVEL
134  115600  051 29.468 N  000 33.742 W  80.00      63.00  .0000  .0000
ITER     ELEV     GEOM      SAT     S-LA     S-LO     S-VN     RMS      FREQ
03         33.     S-E      30190    .0128    .0202    .0000    .0088  -6.2305

S-UPDATE     -.01689780     -.17587693      .17666778
C-WHDG  C-WSPD
 170.0  .0115
  UPDATE
01    .02589404      .00004068      .00001779     -.00000432
02   -.00098975     -.00000093     -.00000180      .00000008
03    .00230175      .00000173      .00000346     -.00000016

400 VNFIX ACO-SY-75030
0000111111111111111111111111111111111111100
                        ^^
DAY        TIME       LAT         LON         ANT        HDG     SPD     NVEL
134  115600  051 29.500 N  000 33.393 W  80.00      63.00  .0000 -.9094
ITER     ELEV     GEOM      SAT     S-LA     S-LO     S-VN     RMS      FREQ
03         33.     S-E      30190    .0389    .0848    .2187    .0050  -6.1621

S-UPDATE      .01580590      .04170537      .04460006
C-WHDG  C-WSPD
 2.388  .0002
N-UPDATE
```

Figure 1: SECTION OF ORIGINAL TELETYPE LOG

poor fix.

APPENDIX A LISTING OF PROGRAM/SAT1 AND THE PRINTOUT PRODUCED BY IT

```
* #4141TAJ   / SAT1-SY;SATNAV THURSDAY APR 24, 1975 9:00:59 AM
$   CARD
C     SAT1 SORTS THE ROUGH DATA FROM FILE SATDAT INTO FILE SATD
        REAL LATM, LONM
        INTEGER DAY, TIME, SAT, UPD, DNS, DEW, TLAT, TLON
      DIMENSION AUP(3), TFIX(3)
        DATA AUP /'UPDA -UP       ' / , TLAT, TLON / 51, 0 /
        DATA TFIX / 'FIX UNFI       ' /
C     READ IN A RECORD, EXIT TO 1000 IF NO MORE DATA
        OPEN (1, INPUT, / SATDAT-DA)
        OPEN (2, OUTPUT, / SATD-DA)
        PRINT ('SATNAV DATA SORT ROUTINE')
        ICNT=0
10      READ (1, 5, END=100) I1, TFIX(3)
5       FORMAT ( / I3, 1X, A4)
        READ (1, 15) DAY, TIME, LATD, LATM, DNS, LOND, LONM,
      &   DEW, ANT, HDG, SPD, NVEL
15      FORMAT ( / / / 3I, F, A1, I, F, A1, 4F)
        READ (1,20) ITER, ELEV, GEOM, SAT, SLA, SLO, SVN, RMS, FREQ
20      FORMAT ( / I, F, A3, I, 5F)
        READ (1,25) AUP(3)
25      FORMAT ( / / / A4)
C     TEST THAT LAT AND LONG ARE CORRECT
        IF (LATD. EQ. TLAT. AND. LOND. EQ. TLON) GOTO 27
        PRINT ('LAT/LON ERROR ON RECORD = ' , I), ICNT
        PRINT ('LAT = ', I, 'LON=  ', I), LATD, LOND
      GOTO 35
```

```
C     TEST THAT FIX IS OKAY
27      IF(TFIX(3).EQ.TFIX(2). OR.TFIX(3).EQ.TFIX(1)) GOTO 28
        PRINT (' HELP TFIX, RECORD =  ', I), ICNT
        STOP
C     TEST THAT UPDATE IS OKAY
28      IF(AUP(3).EQ.AUP(2).OR.AUP(3).EQ.AUP(1)) GOTO 29
        PRINT ('HELP UPD, RECORD =  ', I), ICNT
        STOP
C     SET UP OUTPUT RECORD
29      WRITE (2, 30) DAY, TIME, LATD, LATM, DNS, LOND, LONM, DEW,
     &    ANT, HDG, SPD, NVEL, TFIX(3), AUP(3),
     &    INTER, ELEV, GEOM, SAT, SLA, SLO, SVN, RMS, FREQ
30    FORMAT (3(I, 1X), F, 1X, A1, 1X, I, 1X, F, 1X, A1, 4(1X, F),
     & 2(1X, A4), 1X, I, 1X, F, 1X, A3, 1X, I, 5(1X, F))
35      ICNT = ICNT + 1
        GOTO 10
100   PRINT (' NUMBER OF RECORDS =  ', I), ICNT
      PRINT (' RECORDS STORED IN  / SATD-DAT')
      CLOSE
      STOP
        END
```

```
PROGRAM OUTPUT


SATNAV DATA SORT ROUTINE
LAT/LON ERROR ON RECORD = 19
     LAT = 55  LON = 6
LAT/LON ERROR ON RECORD = 20
     LAT = 55  LON = 8
NUMBER OF RECORDS = 318
RECORDS STORED IN /SATD-DAT
(3 MAIN) 100S + 3


ERRONEOUS RECORDS IN / SAT DAT

400 FIX ACO-SY-75030
0000011111111111111111111111111111100000
                  ^^
DAY TIME LAT LON ANT HDG SPD NVEL
063 004800 055 05.979 N 006 07.551 W 200.0.0000.0000.0000
ITER ELEV GEOM SAT S-LA S-LO S-VN RMS FREQ
04 29.  S-W 30139 28.52 46.14 .0000 16.93 - 3187.6
S-UPDATE 216.91627 - 203.07232 300.57744
C-WHDG C-WSPD
270.2 39758
N-UPDATE

400 VNFIX ACO-SY-75030
0000111111111111111111111111111100000
                  ^^
DAY TIME LAT LON ANT HDG NVEL
063 004800 055 20.241 N 008 39.002 W 200.0.0000.0000 - 402.0
ITER ELEV GEOM SAT S-LA S-LO S-VN RMS FREQ
```

02 29. S-W 30130 176.6 350.0 897.9 18.49 -3044.6

S-UPDATE 231.20412 - 302.54082 380.77074

C-WHDG C-WSPD

270.1 64821

N-UPDATE

APPENDIX B: Listing of Data File SATD

```
62 153300 51 29.544 N 0 33.629 W 200 0 0 0 FIX  N-UP 4 6.1 N-W 30140 .0228 .0722 0 .0018 -10.41
62 162800 51 29.483 N 0 33.579 W 200 0 0 0 FIX  UPDA 3 15 N-W 30120 .0181 .0215 0 .0033 -7.3828
62 164700 51 29.468 N 0 33.805 W 200 0 0 0 FIX  UPDA 3 35 S-E 30190 .0046 .0073 0 .0034 -8.0078
62 164700 51 29.473 N 0 33.75 W 200 0 0 0 VNFI N-UP 3 35 S-E 30190 .0185 .0512 .151 .0033 -8.0078
62 183400 51 29.459 N 0 33.474 W 200 0 0 0 FIX  UPDA 3 49 S-W 30190 .0038 .0102 0 .0041 -6.8848
62 183400 51 29.465 N 0 33.518 W 200 0 0 0 VNFI N-UP 3 49 S-W 30190 .0138 .0361 .0839 .0037 -6.9336
62 190600 51 29.468 N 0 33.913 W 200 0 0 0 FIX  UPDA 3 52 S-E 30180 .0061 .0167 0 .0071 -6.8067
62 190600 51 29.473 N 0 33.787 W 200 0 0 0 VNFI N-UP 3 52 S-E 30180 .0167 .054 .1243 .0056 -6.7969
62 201900 51 29.483 N 0 33.653 W 200 0 0 0 FIX  UPDA 3 10 S-W 30190 .0255 .0335 0 .0022 -6.6016
62 205300 51 29.458 N 0 33.546 W 200 0 0 0 FIX  UPDA 3 34 S-W 30180 .0058 .0102 0 .0045 -6.4063
62 205300 51 29.473 N 0 33.665 W 200 0 0 0 VNFI N-UP 3 34 S-W 30180 .0212 .0451 .126 .0034 -6.3379
62 211500 51 29.465 N 0 33.774 W 200 0 0 0 FIX  UPDA 3 22 S-E 30130 .0082 .009 0 .0033 -6.3867
62 211500 51 29.467 N 0 33.756 W 200 0 0 0 VNFI N-UP 3 22 S-E 30130 .055 .1139 .3284 .0034 -6.377
62 220900 51 29.466 N 0 33.557 W 200 0 0 0 FIX  UPDA 3 35 N-W 30200 .0076 .0135 0 .0064 -6.0547
62 220900 51 29.487 N 0 33.745 W 200 0 0 0 VNFI N-UP 3 35 N-W 30200 .0079 .0316 .0899 .0025 -5.9863
62 223800 51 29.391 N 0 33.68 W 200 0 0 0 FIX  N-UP 3 5.9 S-W 30180 .0381 .0477 0 .0024 -5.1465
62 230000 51 9.855 N 0 7.503 E 200 0 0 0 FIX  N-UP 2 29 S-E 30140 16.45 27.63 0 10.16 484.81
62 230000 51 39.734 N 0 12.509 E 200 0 0 -200 VNFI N-UP 2 19 S-E 30140 192.8 383.1 1257.6 570 -69.18
62 235400 51 29.459 N 0 33.765 W 200 0 0 0 FIX  UPDA 3 10 S-E 30120 .0288 .0257 0 .0019 -5.4785
63 14200 51 29.468 N 0 33.897 W 200 0 0 0 FIX  UPDA 3 50 S-E 30120 .0066 .0168 0 .0073 -5.3711
63 14200 51 29.476 N 0 33.727 W 200 0 0 0 VNFI N-UP 3 50 S-E 30120 .0126 .0335 .0783 .0033 -5.3906
63 23300 51 29.472 N 0 33.598 W 200 0 0 0 FIX  UPDA 3 15 S-W 30140 .0121 .0149 0 .0025 -5.4981
63 30900 51 29.39 N 0 33.676 W 200 0 0 0 FIX  UPDA 3 10 N-E 30190 .0323 .0349 0 .0019 -6.3086
63 32800 51 29.452 N 0 33.532 W 200 0 0 0 FIX  UPDA 3 36 S-W 30120 .0048 .0091 0 .0039 -5.127
63 32800 51 29.465 N 0 33.623 W 200 0 0 0 VNFI N-UP 3 36 S-W 30120 .0143 .0332 .089 .0027 -5.127
63 45400 51 29.453 N 0 33.846 W 200 0 0 0 FIX  UPDA 3 44 N-E 30190 .0042 .0093 0 .0037 -5.2246
63 45400 51 29.463 N 0 33.766 W 200 0 0 0 VNFI N-UP 3 44 N-E 30190 .0073 .0346 .0763 .003 -5.2441
63 51200 51 29.44 N 0 33.688 W 200 0 0 0 FIX  N-UP 3 7.1 S-W 30120 .0356 .0434 0 .0024 -4.541
63 52700 51 29.456 N 0 33.784 W 200 0 0 0 FIX  UPDA 3 12 N-E 30180 .0092 .0091 0 .0011 -5.0977
63 64000 51 29.474 N 0 33.53 W 200 0 0 0 FIX  UPDA 3 46 N-W 30190 .006 .0141 0 .0055 -5.1172
63 64000 51 29.482 N 0 33.598 W 200 0 0 0 VNFI N-UP 3 46 N-W 30190 .0105 .0492 .1109 .0041 -5.0586
63 71300 51 29.449 N 0 34.01 W 200 0 0 0 FIX  UPDA 3 58 N-E 30180 .0055 .0195 0 .0065 -5.0488
63 71300 51 29.464 N 0 33.858 W 200 0 0 0 VNFI N-UP 3 58 N-E 30180 .0041 .0261 .0482 .0025 -5.0293
63 82900 51 29.432 N 0 33.655 W 200 0 0 0 FIX  UPDA 3 10 N-W 30190 .0342 .0299 0 .0018 -5.5664
63 174600 51 29.477 N 0 34.033 W 61.99 .2636 0 0 FIX  N-UP 6 84 S-E 30190 .0067 .1284 0 .0086 -4.9707
63 174600 51 29.45 N 0 32.825 W 61.99 .2636 0 0 VNFI N-UP 3 84 S-E 30190 .0103 .3917 .1363 .0056 -4.9707
63 181700 51 29.481 N 0 33.704 W 61.99 .2636 0 0 FIX  UPDA 4 27 S-E 30180 .0031 .0042 0 .0019 -4.668
63 181700 51 29.484 N 0 33.673 W 61.99 .2636 0 0 VNFI N-UP 5 27 S-E 30180 .0153 .0345 .1015 .0017 -4.6777
63 193200 51 29.499 N 0 33.726 W 80 0 0 0 FIX  N-UP 3 20 S-W 30190 .0146 .0265 0 .0016 -4.9316
63 193200 51 29.49 N 0 33.773 W 80 0 0 0 VNFI N-UP 2 20 S-W 30190 .0368 .8483 3.21 .0018 -4.5898
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63 200400 51 29.48 N 0 33.633 W 80 0 0 0 FIX  UPDA 3 65 S-W 30180 .0049 .0222 0 .0059 -4.3945
63 200400 51 29.493 N 0 33.79 W 80 0 0 0 VNFI N-UP 3 65 S-W 30180 .0071 .0311 .0457 .0026 -4.4238
63 202500 51 29.479 N 0 33.703 W 80 0 0 0 FIX  UPDA 3 11 S-E 30130 .0357 .0369 0 .0035 -4.5605
63 210200 51 29.478 N 0 33.325 W 80 0 0 0 FIX  N-UP 3 86 N-E 30200 .0084 .1746 0 .0051 -4.5117
63 210200 51 29.459 N 0 33.948 W 80 0 0 0 VNFI N-UP 2 86 N-E 30200 .1214 2.284 .3901 .0049 -4.5312
63 215000 51 29.495 N 0 33.666 W 80 0 0 0 FIX  UPDA 3 14 S-W 30180 .0136 .013 0 .0023 -4.4336
63 220800 51 29.424 N 0 33.665 W 80 0 0 0 FIX  UPDA 3 14 S-E 30140 .0192 .0189 0 .0034 -3.4863
63 224800 51 29.466 N 0 33.655 W 80 0 0 0 FIX  UPDA 3 19 N-W 30200 .0093 .0123 0 .0031 -4.1992
63 235600 51 29.464 N 0 33.76 W 80 0 0 0 FIX  UPDA 3 65 S-E 30140 .0071 .03 0 .009 -4.082
63 235600 51 29.474 N 0 33.497 W 80 0 0 0 VNFI N-UP 3 65 S-E 30140 .0175 .0686 .1133 .0048 -4.082
64 4600 51 29.49 N 0 33.679 W 80 0 0 0 FIX  UPDA 3 24 S-E 30120 .0039 .0051 0 .002 -3.7598
64 4600 51 29.484 N 0 33.72 W 80 0 0 0 VNFI N-UP 3 24 S-E 30120 .0224 .0504 .1471 .0019 -3.7695
64 14200 51 29.46 N 0 33.682 W 80 0 0 0 FIX  UPDA 3 29 S-W 30140 .0091 .016 0 .0057 -3.9648
64 14200 51 29.483 N 0 33.84 W 80 0 0 0 VNFI N-UP 3 29 S-W 30140 .0424 .0923 .252 .005 -3.9844
64 23300 51 29.481 N 0 33.612 W 80 0 0 0 FIX  N-UP 3 75 S-W 30120 .0052 .0421 0 .0063 -3.8965
64 23300 51 29.497 N 0 33.87 W 80 0 0 0 VNFI N-UP 3 75 S-W 30120 .0071 .0442 .0346 .0024 -3.8867
64 32600 51 29.567 N 0 33.613 W 80 0 0 0 FIX  N-UP 3 4.8 S-W 30140 .0406 .0497 0 .002 -5.2148
64 40600 51 29.479 N 0 33.708 W 80 0 0 0 FIX  UPDA 3 24 N-E 30190 .0093 .0126 0 .0045 -3.9844
64 40600 51 29.46 N 0 33.819 W 80 0 0 0 VNFI N-UP 3 24 N-E 30190 .0248 .1117 .3002 .0041 -3.9648
64 55200 51 29.502 N 0 33.683 W 80 0 0 0 FIX  N-UP 3 83 N-W 30190 .0074 .0814 0 .0075 -3.5547
64 55200 51 29.517 N 0 33.09 W 80 0 0 0 VNFI N-UP 2 83 N-W 30190 .0232 .2552 .1235 .0057 -3.4375
64 61100 51 29.564 N 0 33.878 W 80 0 0 0 FIX  N-UP 3 7.9 S-E 30200 .0474 .0459 0 .0023 -6.1035
64 62400 51 29.459 N 0 33.728 W 80 0 0 0 FIX  UPDA 3 30 N-E 30180 .0033 .0108 0 .0018 -3.7695
64 62400 51 29.458 N 0 33.745 W 80 0 0 0 VNFI N-UP 3 30 N-E 30180 .0164 .1263 .4978 .0024 -3.7402
64 74000 51 29.474 N 0 33.657 W 80 0 0 0 FIX  UPDA 3 20 N-W 30190 .0072 .0074 0 .0023 -3.8769
64 74000 51 29.49 N 0 33.801 W 80 0 0 0 VNFI N-UP 3 20 N-W 30190 .0308 .1171 .3188 .0022 -3.9648
64 75800 51 29.494 N 0 33.731 W 80 0 0 0 FIX  UPDA 3 39 S-E 30200 .0096 .016 0 .0064 -4.6484
64 75800 51 29.493 N 0 33.81 W 80 0 0 0 VNFI N-UP 3 39 S-E 30200 .0293 .1214 .332 .0061 -4.7363
64 83400 51 29.475 N 0 33.829 W 80 0 0 0 FIX  UPDA 3 12 N-E 30130 .04 .0632 0 .004 -3.8965
64 94400 51 29.476 N 0 33.604 W 80 0 0 0 FIX  UPDA 3 51 S-W 30200 .0095 .0259 0 .0096 -4.8535
64 94400 51 29.502 N 0 33.824 W 80 0 0 0 VNFI N-UP 3 51 S-W 30200 .0257 .0653 .132 .006 -4.873
64 101600 51 29.511 N 0 33.76 W 80 0 0 0 FIX  N-UP 3 14 N-E 30140 .0143 .1016 0 .0029 -3.7891
64 120100 51 29.48 N 0 33.838 W 80 26.8 .0744 0 FIX  UPDA 3 65 N-E 30140 .0049 .0404 0 .0055 -4.6582
64 120100 51 29.48 N 0 33.846 W 80 26.8 .0744 0 VNFI N-UP 3 65 N-E 30140 .0287 .2388 .5762 .0054 -4.6484
64 125000 51 29.47 N 0 33.794 W 80 0 0 0 FIX  UPDA 3 26 N-E 30120 .0073 .011 0 .0043 -4.1992
64 125000 51 29.49 N 0 33.697 W 80 0 0 0 VNFI N-UP 3 26 N-E 30120 .015 .0822 .2369 .0031 -4.1309
64 134800 51 29.493 N 0 33.6 W 80 0 0 0 FIX  UPDA 3 29 N-W 30140 .0145 .0228 0 .0089 -4.[illegible]285
64 134800 51 29.532 N 0 33.842 W 80 0 0 0 VNFI N-UP 3 29 N-W 30140 .0255 .1419 .4204 .00[illegible]8 -4.0625
64 143600 51 29.481 N 0 33.567 W 80 0 0 0 FIX  UPDA 2 68 N-W 30120 .0046 .0197 0 .0052 -[illegible].1113
64 143600 51 29.487 N 0 33.741 W 80 0 0 0 VNFI N-UP 3 68 N-W 30120 .0071 .0497 .0746 .00[illegible]2 -4.0332
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64 150800 51 29.522 N 0 33.719 W 80 0 0 0 FIX  N-UP 3 8.4 S-E 30190 .0383 .0519 0 .0028 -5.2344
64 162400 51 29.534 N 0 33.684 W 80 0 0 0 FIX  UPDA 3 14 N-W 30120 .0138 .0133 0 .0025 -3.0762
64 165700 51 29.488 N 0 33.758 W 80 0 0 0 FIX  UPDA 3 45 S-E 30190 .0058 .013 0 .006 -4.7852
64 165700 51 29.496 N 0 33.655 W 80 0 0 0 VNFI N-UP 3 45 S-E 30190 .0196 .0472 .1255 .0046 -4.8242
64 172700 51 29.473 N 0 33.664 W 80 0 0 0 FIX  UPDA 3 13 S-E 30180 .0217 .0211 0 .0038 -4.4336
64 184400 51 29.486 N 0 33.668 W 80 5.976 .0166 0 FIX  UPDA 3 38 S-W 30190 .0076 .0141 0 .006 -5.4981
64 184400 51 29.497 N 0 33.757 W 80 5.976 .0166 0 VNFI N-UP 3 38 S-W 30190 .0249 .0478 .1283 .0039 -5.4785
64 191500 51 29.473 N 0 33.757 W 80 5.976 .0166 0 FIX  UPDA 3 66 S-E 30180 .0023 .0098 0 .0028 -5
64 191500 51 29.473 N 0 33.744 W 80 5.976 .0166 0 VNFI N-UP 3 66 S-E 30180 .0076 .0357 .0572 .003 -4.9805
64 193400 51 29.324 N 0 33.715 W 80 5.976 .0166 0 FIX  N-UP 3 4.2 S-E 30130 .1014 .1201 0 .0043 -3.6426
64 195500 51 29.462 N 0 33.683 W 80 5.976 .0166 0 FIX  UPDA 3 37 N-E 30200 .0055 .0109 0 .0047 -5.1367
64 195500 51 29.477 N 0 33.596 W 80 5.976 .0166 0 VNFI N-UP 3 37 N-E 30200 .0073 .0352 .0971 .0029 -5.1074
64 202800 51 29.626 N 0 33.115 W 80 5.976 .0166 0 FIX  N-UP 3 7.3 S-W 30190 .067 .1037 0 .0054 -9.4336
64 210100 51 29.445 N 0 33.66 W 80 5.976 .0166 0 FIX  UPDA 3 27 S-W 30180 .007 .0096 0 .0038 -4.209
64 210100 51 29.445 N 0 33.823 W 80 5.976 .0166 0 VNFI N-UP 3 27 S-W 30180 .0196 .0481 .1425 .0022 -4.1699
64 212400 51 29.465 N 0 33.718 W 80 5.976 .0166 0 FIX  UPDA 3 29 S-E 30130 .0088 .0132 0 .0055 -4.668
64 212400 51 29.479 N 0 33.638 W 80 5.976 .0166 0 VNFI N-UP 3 29 S-E 30130 .0484 .1104 .3053 .0052 -4.6875
64 214000 51 29.472 N 0 33.673 W 80 5.976 .0166 0 FIX  N-UP 3 48 N-W 30200 .0031 .0286 0 .0025 -4.7656
64 214000 51 29.466 N 0 33.64 W 80 5.976 .0166 0 VNFI N-UP 2 48 N-W 30200 .0748 .3853 1.891 .0026 -4.9512
64 230400 51 29.487 N 0 33.709 W 80 5.976 .0166 0 FIX  UPDA 3 34 S-E 30140 .006 .0092 0 .0041 -4.3066
64 230400 51 29.49 N 0 33.598 W 80 5.976 .0166 0 VNFI N-UP 3 34 S-E 30140 .0325 .068 .1812 .0041 -4.1992
64 232800 51 29.52 N 0 33.563 W 80 5.976 .0166 0 FIX  N-UP 3 9.9 N-W 30200 .0202 .0224 0 .0014 -3.4765
64 235000 51 29.434 N 0 33.683 W 80 5.976 .0166 0 FIX  UPDA 3 10 S-E 30120 .0352 .0286 0 .0025 -3.457
65 5100 51 29.472 N 0 33.659 W 80 5.976 .0166 0 FIX  UPDA 3 56 S-W 30140 .006 .0197 0 .0067 -4.0723
65 5100 51 29.483 N 0 33.777 W 80 5.976 .0166 0 VNFI N-UP 3 56 S-W 30140 .0172 .0521 .0957 .005 -4.1211
65 13800 51 29.485 N 0 33.728 W 80 5.976 .0166 0 FIX  UPDA 3 53 S-E 30120 .0034 .0094 0 .0039 -4.1601
65 13800 51 29.489 N 0 33.66 W 80 5.976 .0166 0 VNFI N-UP 3 53 S-E 30120 .0065 .0225 .0502 .0022 -4.1601
65 23600 51 29.479 N 0 33.636 W 80 5.976 .0166 0 FIX  UPDA 3 12 S-W 30140 .0196 .0232 0 .0025 -4.2578
65 31800 51 29.453 N 0 33.705 W 80 5.976 .0166 0 FIX  UPDA 3 13 N-E 30190 .016 .0172 0 .0023 -4.4238
65 50400 51 29.483 N 0 33.698 W 80 5.976 .0166 0 FIX  UPDA 3 55 N-E 30190 .004 .0125 0 .0042 -4.0039
65 50400 51 29.487 N 0 33.667 W 80 5.976 .0166 0 VNFI N-UP 3 55 N-E 30190 .0076 .047 .0833 .0043 -3.9844
65 53500 51 29.463 N 0 33.701 W 80 5.976 .0166 0 FIX  UPDA 3 16 N-E 30180 .008 .0083 0 .0019 -4.2285
65 65000 51 29.48 N 0 33.67 W 80 5.976 .0166 0 FIX  UPDA 3 37 N-W 30190 .0059 .0095 0 .0042 -4.1797
65 65000 51 29.484 N 0 33.726 W 80 5.976 .0166 0 VNFI N-UP 3 37 N-W 30190 .0217 .0716 .1774 .0048 -4.1894
65 72100 51 29.475 N 0 33.874 W 80 5.976 .0166 0 FIX  N-UP 3 74 N-E 30180 .0074 .0547 0 .0094 -3.9648
65 72100 51 29.495 N 0 33.545 W 80 5.976 .0166 0 VNFI N-UP 3 74 N-E 30180 .004 .0521 .0473 .0032 -3.9746
65 83700 51 29.489 N 0 33.908 W 80 5.976 .0166 0 FIX  UPDA 3 70 S-E 30200 .0077 .0397 0 .0099 -4.9219
65 83700 51 29.494 N 0 33.573 W 80 5.976 .0166 0 VNFI N-UP 3 70 S-E 30200 .013 .0745 .0938 .005 -4.9609
65 90800 51 29.468 N 0 33.628 W 80 5.976 .0166 0 FIX  UPDA 3 23 N-W 30180 .0073 .0095 0 .0033 -4.1894
65 90800 51 29.499 N 0 33.857 W 80 5.976 .0166 0 VNFI N-UP 3 23 N-W 30180 .0077 .0597 .1859 .0017 -4.1309
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65 92500 51 29.431 N 0 33.793 W 80 5.976 .0166 0 FIX  N-UP 3 6.2 N-E 30140 .0263 .1124 0 .0029 -3.9258
65 102200 51 29.473 N 0 33.582 W 80 5.976 .0166 0 FIX  UPDA 3 29 S-W 30200 .0106 .0162 0 .0064 -4.9512
65 102200 51 29.512 N 0 33.841 W 80 5.976 .0166 0 VNFI N-UP 3 29 S-W 30200 .0356 .0792 .2124 .0041 -4.9609
65 111000 51 29.473 N 0 33.773 W 80 5.976 .0166 0 FIX  UPDA 3 33 N-E 30140 .0096 .0169 0 .0069 -3.8574
65 111000 51 29.507 N 0 33.554 W 80 5.976 .0166 0 VNFI N-UP 3 33 N-E 30140 .0099 .0715 .1897 .0043 -3.7793
65 115600 51 29.503 N 0 33.866 W 80 5.976 .0166 0 FIX  UPDA 3 12 N-E 30120 .0198 .0302 0 .0021 -2.8613
65 125600 51 29.488 N 0 33.621 W 80 5.976 .0166 0 FIX  UPDA 3 56 N-W 30140 .0052 .0161 0 .0062 -3.9062
65 125600 51 29.492 N 0 33.701 W 80 5.976 .0166 0 VNFI N-UP 3 56 N-W 30140 .0133 .0562 .1129 .0055 -3.916
65 134100 51 29.473 N 0 33.819 W 80 5.976 .0166 0 FIX  UPDA 3 58 N-E 30120 .0072 .0253 0 .0085 -3.75
65 134100 51 29.491 N 0 33.62 W 80 5.976 .0166 0 VNFI N-UP 3 58 N-E 30120 .0055 .0336 .0611 .0034 -3.75
65 144400 51 29.52 N 0 33.58 W 80 12.04 .0334 0 FIX  UPDA 3 12 N-W 30140 .0262 .0264 0 .003 -2.8222
66 185300 51 29.478 N 0 33.617 W 80 12.04 .0334 0 FIX  UPDA 3 29 S-W 30190 .0063 .0105 0 .0043 -3.9551
66 185300 51 29.5 N 0 33.733 W 80 12.04 .0334 0 VNFI N-UP 3 29 S-W 30190 .0291 .0516 .1559 .0032 -4.0234
66 192300 51 29.485 N 0 34.094 W 80 12.04 .0334 0 FIX  N-UP 3 83 S-E 30180 .0066 .0698 0 .0061 -3.9453
66 192300 51 29.468 N 0 33.386 W 80 12.04 .0334 0 VNFI N-UP 3 83 S-E 30180 .0061 .1265 .0647 .0027 -3.916
66 194400 51 29.392 N 0 33.695 W 80 12.04 .0334 0 FIX  N-UP 3 6.7 S-E 30130 .0738 .0849 0 .004 -3.2324
66 203800 51 29.586 N 0 33.525 W 80 12.04 .0334 0 FIX  N-UP 3 4.6 S-W 30190 .1018 .0816 0 .0051 -5.8106
66 210900 51 29.462 N 0 33.654 W 80 12.04 .0334 0 FIX  UPDA 3 21 S-W 30180 .0084 .0145 0 .0026 -3.6621
66 210900 51 29.479 N 0 33.722 W 80 12.04 .0334 0 VNFI N-UP 3 21 S-W 30180 .0535 .1077 .3469 .0021 -3.7793
66 213400 51 29.478 N 0 33.71 W 80 12.04 .0334 0 FIX  UPDA 3 36 S-E 30130 .0086 .0168 0 .0069 -4.082
66 213400 51 29.486 N 0 33.606 W 80 12.04 .0334 0 VNFI N-UP 3 36 S-E 30130 .0352 .0778 .2033 .0052 -4.1016
66 225900 51 29.508 N 0 33.663 W 80 12.04 .0334 0 FIX  UPDA 3 14 N-W 30200 .0181 .0195 0 .0032 -3.2715
66 232000 51 29.47 N 0 33.653 W 80 12.04 .0334 0 FIX  UPDA 3 51 S-W 30130 .0078 .0217 0 .0082 -4.1113
66 232000 51 29.487 N 0 33.79 W 80 12.04 .0334 0 VNFI N-UP 3 51 S-W 30130 .0232 .0651 .1368 .0063 -4.1309
66 234600 51 29.449 N 0 33.723 W 80 12.04 .0334 0 FIX  UPDA 3 11 S-E 30120 .0193 .0171 0 .0017 -3.2226
67 5500 51 29.479 N 0 33.667 W 80 12.04 .0334 0 FIX  UPDA 3 47 S-W 30140 .0056 .0142 0 .0057 -3.6328
67 5500 51 29.479 N 0 33.695 W 80 12.04 .0334 0 VNFI N-UP 3 47 S-W 30140 .0202 .0534 .1175 .0053 -3.584
67 13400 51 29.469 N 0 33.734 W 80 12.04 .0334 0 FIX  UPDA 3 56 S-E 30120 .0021 .0065 0 .0025 -3.3203
67 13400 51 29.47 N 0 33.711 W 80 12.04 .0334 0 VNFI N-UP 3 56 S-E 30120 .0071 .0253 .0531 .0024 -3.3398
67 24000 51 29.46 N 0 33.614 W 80 12.04 .0334 0 FIX  UPDA 3 10 S-W 30140 .0285 .0338 0 .002 -3.6523
67 32000 51 29.468 N 0 33.657 W 80 12.04 .0334 0 FIX  UPDA 3 33 S-W 30120 .0034 .0069 0 .003 -3.5547
67 32000 51 29.473 N 0 33.689 W 80 12.04 .0334 0 VNFI N-UP 3 33 S-W 30120 .015 .0324 .0889 .0023 -3.5449
67 50400 51 29.436 N 0 33.666 W 80 12.04 .0334 0 FIX  N-UP 3 6 S-W 30120 .0527 .0597 0 .003 -3.1445
67 51400 51 29.441 N 0 33.896 W 80 12.04 .0334 0 FIX  N-UP 3 68 N-E 30190 .02 .1675 0 .0048 -3.5156
67 51400 51 29.295 N 0 34.59 W 80 12.04 .0334 -2 VNFI N-UP 2 67 N-E 30190 .6341 3.091 9.32 .004 -7.2168
67 54400 51 29.479 N 0 33.722 W 80 12.04 .0334 0 FIX  UPDA 3 20 N-E 30180 .0033 .004 0 .0012 -3.418
67 54400 51 29.486 N 0 33.671 W 80 12.04 .0334 0 VNFI N-UP 3 20 N-E 30180 .0092 .0617 .1896 .0015 -3.457
67 62200 51 29.46 N 0 33.762 W 80 12.04 .0334 0 FIX  UPDA 3 12 S-E 30200 .0207 .0207 0 .0021 -4.1699
67 70000 51 29.461 N 0 33.679 W 80 12.04 .0334 0 FIX  UPDA 3 29 N-W 30190 .0052 .0073 0 .0032 -3.8672
67 70000 51 29.458 N 0 33.656 W 80 12.04 .0334 0 VNFI N-UP 3 29 N-W 30190 .0149 .0654 .1727 .0033 -3.8672
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67 72900 51 29.496 N 0 33.192 W 80 12.04 .0334 0 FIX  N-UP 3 84 N-W 30180 .0049 .0774 0 .0038 -3.5156
67 72900 51 29.468 N 0 34.292 W 80 12.04 .0334 0 VNFI N-UP 3 84 N-W 30180 .0154 .2549 .0691 .0021 -3.5742
67 80900 51 29.485 N 0 33.828 W 80 12.04 .0334 0 FIX  UPDA 3 53 S-E 30200 .0069 .019 0 .0076 -4.4043
67 80900 51 29.49 N 0 33.684 W 80 12.04 .0334 0 VNFI N-UP 3 53 S-E 30200 .0181 .0574 .1192 .0052 -4.3945
67 91700 51 29.486 N 0 33.644 W 80 12.04 .0334 0 FIX  UPDA 3 18 N-W 30180 .0048 .0066 0 .0012 -3.3984
67 94000 51 29.483 N 0 33.759 W 80 12.04 .0334 0 FIX  UPDA 3 39 N-E 30130 .0114 .0247 0 .0095 -4.0332
67 94000 51 29.51 N 0 33.579 W 80 12.04 .0334 0 VNFI N-UP 3 39 N-E 30130 .0136 .0773 .1962 .0066 -3.8965
67 95600 51 29.508 N 0 33.813 W 80 12.04 .0334 0 FIX  N-UP 3 34 S-W 30200 .0218 .2335 0 .0057 -5.0684
67 95600 51 30.502 N 0 29.286 W 80 12.04 .0334 21 VNFI N-UP 2 34 S-W 30200 3.168 14.56 67.64 .0067 -34.648
67 111300 51 29.485 N 0 33.759 W 80 10.63 .0295 0 FIX  UPDA 3 39 N-E 30140 .0099 .0205 0 .008 -3.4082
67 111300 51 29.516 N 0 33.555 W 80 10.63 .0295 0 VNFI N-UP 3 39 N-E 30140 .0094 .0775 .2045 .0054 -3.2812
67 113800 51 29.406 N 0 33.733 W 80 10.63 .0295 0 FIX  N-UP 3 8.3 S-W 30200 .0632 .0769 0 .0037 -3.1738
67 115200 51 29.524 N 0 33.874 W 80 10.63 .0295 0 FIX  UPDA 3 13 N-E 30120 .0216 .0336 0 .0028 -1.9238
67 130000 51 29.49 N 0 33.648 W 80 10.63 .0295 0 FIX  UPDA 3 47 N-W 30140 .0082 .0213 0 .008 -3.7207
67 130000 51 29.512 N 0 33.816 W 80 10.63 .0295 0 VNFI N-UP 3 47 N-W 30140 .0101 .0587 .1441 .005 -3.4765
67 133800 51 29.464 N 0 33.825 W 80 10.63 .0295 0 FIX  UPDA 3 61 N-E 30120 .0054 .0217 0 .0064 -3.5449
67 133800 51 29.48 N 0 33.685 W 80 10.63 .0295 0 VNFI N-UP 3 61 N-E 30120 .0037 .0389 .0664 .0033 -3.4668
67 144800 51 29.47 N 0 33.679 W 80 10.63 .0295 0 FIX  UPDA 3 10 N-W 30140 .0291 .0355 0 .002 -3.8672
67 152400 51 29.477 N 0 33.624 W 80 10.63 .0295 0 FIX  UPDA 3 29 N-W 30120 .0076 .0118 0 .0048 -3.4375
67 152400 51 29.499 N 0 33.812 W 80 10.63 .0295 0 VNFI N-UP 3 29 N-W 30120 .0129 .0588 .1751 .0031 -3.3496
67 161800 51 29.473 N 0 33.758 W 80 10.63 .0295 0 FIX  UPDA 3 29 S-E 30190 .0066 .0103 0 .0047 -3.6914
67 161800 51 29.488 N 0 33.623 W 80 10.63 .0295 0 VNFI N-UP 3 29 S-E 30190 .0238 .0535 .1623 .0034 -3.7598
67 164500 51 29.509 N 0 33.688 W 80 10.63 .0295 0 FIX  N-UP 3 8.1 S-E 30180 .0347 .0403 0 .0022 -3.8183
67 180500 51 29.475 N 0 33.591 W 80 10.63 .0295 0 FIX  UPDA 3 56 S-W 30190 .0054 .018 0 .0065 -3.8281
67 180500 51 29.489 N 0 33.722 W 80 10.63 .0295 0 VNFI N-UP 3 56 S-W 30190 .0129 .0363 .0725 .004 -3.8672
67 182200 51 29.453 N 0 33.745 W 80 10.63 .0295 0 FIX  UPDA 3 11 N-E 30200 .0232 .0647 0 .0029 -4.2383
67 183400 51 29.49 N 0 33.712 W 80 10.63 .0295 0 FIX  N-UP 3 43 S-E 30180 .0057 .0375 0 .0026 -4.1113
67 183400 51 29.543 N 0 34.079 W 80 10.63 .0295 1 VNFI N-UP 2 43 S-E 30180 .0782 .5607 2.751 .0024 -6.6797
67 195000 51 29.466 N 0 33.642 W 80 10.63 .0295 0 FIX  UPDA 3 11 S-W 30190 .0297 .0354 0 .0031 -3.8867
67 200500 51 29.465 N 0 33.732 W 80 10.63 .0295 0 FIX  UPDA 3 51 N-E 30200 .0048 .016 0 .0049 -4.3066
67 200500 51 29.49 N 0 33.592 W 80 10.63 .0295 0 VNFI N-UP 3 51 N-E 30200 .0044 .064 .1705 .0039 -4.0039
67 202200 51 29.485 N 0 33.775 W 80 10.63 .0295 0 FIX  N-UP 3 37 S-W 30180 .0057 .0766 0 .0023 -4.3262
67 202200 51 28.238 N 0 39.162 W 80 10.63 .0295 -29 VNFI N-UP 2 38 S-W 30180 1.219 5.354 28.64 .0017 38.65
67 204400 51 29.458 N 0 33.724 W 80 10.63 .0295 0 FIX  UPDA 3 19 S-E 30130 .0125 .0148 0 .0045 -4.2871
67 215100 51 29.475 N 0 33.68 W 80 10.63 .0295 0 FIX  UPDA 3 35 N-W 30200 .0061 .0124 0 .0047 -4.1601
67 215100 51 29.481 N 0 33.749 W 80 10.63 .0295 0 VNFI N-UP 3 35 N-W 30200 .0113 .0438 .1222 .0033 -4.209
67 221600 51 29.467 N 0 33.73 W 80 10.63 .0295 0 FIX  UPDA 3 21 S-E 30140 .001 122 .004 -3.6328 0
67 221600 51 29.478 N 0 33.675 W 80 10.63 .0295 0 VNFI N-UP 3 21 S-E 30140 .067 .152 .441 .0037 -3.6621
67 223200 51 29.471 N 0 33.982 W 80 10.63 .0295 0 FIX  N-UP 3 84 S-E 30130 .0048 .1859 0 .0058 -.5898
67 223200 51 29.505 N 0 34.987 W 80 10.63 .0295 0 VNFI N-UP 2 84 S-E 30130 .0156 1.21 .5487 .0053 -5.1074
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67 240300 51 29.441 N 0 31.563 W 80 10.63 .0295 0 VNFI N-UP 2 85 S-E 30140 .0142 12.38 1.591 .0057 -3.5449
68 1800 51 29.489 N 0 33.657 W 80 10.63 .0295 0 FIX  UPDA 3 21 S-W 30130 .0193 .0164 0 .0032 -4.873
68 1800 51 29.483 N 0 33.601 W 80 10.63 .0295 0 VNFI N-UP 3 21 S-W 30130 .0729 .4423 1.385 .0031 -4.8926
68 3900 51 29.479 N 0 33.726 W 80 10.63 .0295 0 FIX  UPDA 3 27 S-E 30120 .0041 .0051 0 .0021 -4.3848
68 3900 51 29.478 N 0 33.705 W 80 10.63 .0295 0 VNFI N-UP 3 27 S-E 30120 .0186 .0401 .1162 .0018 -4.2969
68 14900 51 29.483 N 0 33.637 W 80 10.63 .0295 0 FIX  UPDA 3 21 S-W 30140 .0124 .0159 0 .0048 -3.7793
68 14900 51 29.516 N 0 33.832 W 80 10.63 .0295 0 VNFI N-UP 3 21 S-W 30140 .0854 .1591 .4583 .0041 -3.7988
68 22600 51 29.484 N 0 33.621 W 80 10.63 .0295 0 FIX  UPDA 3 68 S-W 30120 .0051 .0265 0 .0063 -4.5801
68 22600 51 29.499 N 0 33.795 W 80 10.63 .0295 0 VNFI N-UP 3 68 S-W 30120 .0078 .0316 .0396 .0025 -4.6289
68 41100 51 29.474 N 0 33.614 W 80 10.63 .0295 0 FIX  UPDA 3 15 S-W 30120 .0086 .0097 0 .0018 -4.6777
68 42500 51 29.472 N 0 33.66 W 80 10.63 .0295 0 FIX  N-UP 3 38 N-E 30190 .0068 .0472 0 .003 -3.8769
68 42500 51 29.612 N 0 33.255 W 80 10.63 .0295 1 VNFI N-UP 2 38 N-E 30190 .138 .6255 2.932 .0031 -1.3183
68 45500 51 29.496 N 0 33.796 W 80 10.63 .0295 0 FIX  N-UP 3 9.9 N-E 30180 .021 .0187 0 .0016 -2.5976
68 61200 51 29.49 N 0 33.686 W 80 10.63 .0295 0 FIX  UPDA 3 52 N-W 30190 .0042 .0114 0 .0046 -3.4473
68 61200 51 29.49 N 0 33.695 W 80 10.63 .0295 0 VNFI N-UP 3 52 N-W 30190 .0119 .0478 .0984 .0044 -3.4473
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68 64000 51 29.486 N 0 33.663 W 80 10.63 .0295 0 VNFI N-UP 3 48 N-E 30180 .0045 .0245 .0571 .0026 -3.2519
68 70200 51 29.486 N 0 33.754 W 80 10.63 .0295 0 FIX  UPDA 3 22 S-E 30200 .0104 .011 0 .0038 -4.2187
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68 80000 51 29.492 N 0 33.645 W 80 10.63 .0295 0 FIX  UPDA 3 11 N-W 30190 .0287 .0245 0 .0024 -3.2422
68 82700 51 29.492 N 0 33.646 W 80 10.63 .0295 0 FIX  UPDA 3 35 N-W 30180 .0079 .0139 0 .0063 -3.2031
68 82700 51 29.511 N 0 33.839 W 80 10.63 .0295 0 VNFI N-UP 3 35 N-W 30180 .0081 .0416 .1219 .003 -3.1445
68 84800 51 29.365 N 0 30.372 W 80 10.63 .0295 0 FIX  N-UP 3 86 S-W 30200 .0567 1.394 0 .0189 -4.1894
68 84800 51 29.502 N 0 34.024 W 80 10.63 .0295 0 VNFI N-UP 3 86 S-W 30200 .0218 .5162 .0309 .0046 -4.1309
68 102200 51 29.479 N 0 33.782 W 80 10.63 .0295 0 FIX  UPDA 3 21 N-E 30140 .0147 .0213 0 .0053 -3.125
68 102200 51 29.512 N 0 33.597 W 80 10.63 .0295 0 VNFI N-UP 3 21 N-E 30140 .0156 .2478 .7421 .0051 -3.0371
68 103800 51 29.502 N 0 32.145 W 80 10.63 .0295 0 FIX  N-UP 3 85 N-W 30130 .0226 .9425 0 .0059 -3.9746
68 103800 51 29.301 N 0 48.425 W 80 10.63 .0295 5 VNFI N-UP 2 86 N-W 30130 25.41 994.3 95.32 .1399 .54688
68 120800 51 29.522 N 0 31.586 W 80 10.63 .0295 0 FIX  N-UP 3 86 N-W 30140 .0074 .3123 0 .0064 -3.418
68 120800 51 29.535 N 0 30.897 W 80 10.63 .0295 0 VNFI N-UP 2 86 N-W 30140 .1976 5.871 .6714 .0063 -3.3691
68 122600 51 29.451 N 0 33.652 W 80 10.63 .0295 0 FIX  UPDA 3 20 N-W 30130 .0133 .0153 0 .0049 -4.2773
68 122600 51 29.494 N 0 33.979 W 80 10.63 .0295 0 VNFI N-UP 3 20 N-W 30130 .0328 .1948 .5687 .0042 -4.3066
68 124300 51 29.444 N 0 33.738 W 80 10.63 .0295 0 FIX  UPDA 3 30 N-E 30120 .005 .0119 0 .0028 -3.6523
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68 135600 51 29.541 N 0 33.983 W 80 10.63 .0295 1 VNFI N-UP 3 21 N-W 30140 .0317 .2006 .5814 .0049 -3.0957
68 142900 51 29.469 N 0 33.596 W 80 10.63 .0295 0 FIX  UPDA 3 61 N-W 30120 .0065 .023 0 .0076 -3.4863
68 142900 51 29.482 N 0 33.811 W 80 10.63 .0295 0 VNFI N-UP 3 61 N-W 30120 .0057 .0427 .0866 .0032 -3.3105
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68 161600 51 29.488 N 0 33.596 W 80 10.63 .0295 0 FIX  UPDA 3 12 N-W 30120 .0219 .0293 0 .0023 -2.7441
68 171700 51 29.479 N 0 33.986 W 80 10.63 .0295 0 FIX  N-UP 3 75 S-E 30190 .0066 .0466 0 .0096 -3.9258
68 171700 51 29.479 N 0 33.685 W 80 10.63 .0295 0 VNFI N-UP 3 75 S-E 30190 .014 .1035 .1131 .0063 -3.9746
68 174400 51 29.477 N 0 33.73 W 80 10.63 .0295 0 FIX  UPDA 3 22 S-E 30180 .0053 .0064 0 .0025 -4.5312
68 174400 51 29.47 N 0 33.793 W 80 10.63 .0295 0 VNFI N-UP 3 22 S-E 30180 .0337 .0781 .2315 .0026 -4.5312
68 190000 51 29.474 N 0 33.714 W 80 10.63 .0295 0 FIX  UPDA 3 21 N-E 30200 .0072 .0094 0 .003 -3.8965
68 190000 51 29.5 N 0 33.598 W 80 10.63 .0295 0 VNFI N-UP 3 21 N-E 30200 .0099 .0822 .2448 .0024 -3.8672
68 193200 51 29.46 N 0 33.522 W 80 10.63 .0295 0 FIX  N-UP 3 78 S-W 30180 .0059 .0593 0 .007 -4.3066
68 193200 51 29.474 N 0 33.806 W 80 10.63 .0295 0 VNFI N-UP 2 78 S-W 30180 .0135 .101 .0636 .0045 -4.3262
68 195400 51 29.448 N 0 33.689 W 80 10.63 .0295 0 FIX  N-UP 3 9.7 S-E 30130 .043 .0473 0 .0027 -3.6914
68 204400 51 29.47 N 0 33.597 W 80 10.63 .0295 0 FIX  N-UP 3 85 N-W 30200 .0068 .1329 0 .007 -3.9258
68 204400 51 29.473 N 0 33.538 W 80 10.63 .0295 0 VNFI N-UP 2 85 N-W 30200 .0519 .7808 .2324 .0069 -3.9258
68 211700 51 29.479 N 0 33.661 W 80 10.63 .0295 0 FIX  UPDA 3 17 S-W 30180 .0069 .0081 0 .002 -4.4824
68 214300 51 29.477 N 0 33.735 W 80 10.63 .0295 0 FIX  UPDA 3 47 S-E 30130 .0054 .0124 0 .0054 -4.1699
68 214300 51 29.486 N 0 33.616 W 80 10.63 .0295 0 VNFI N-UP 3 47 S-E 30130 .0143 .0392 .0946 .0036 -4.1797
68 223000 51 29.471 N 0 33.679 W 80 10.63 .0295 0 FIX  UPDA 3 19 N-W 30200 .0101 .0125 0 .0034 -3.6328
68 231200 51 29.487 N 0 33.751 W 80 10.63 .0295 0 FIX  UPDA 3 47 S-E 30140 .006 .0139 0 .0061 -3.584
68 231200 51 29.494 N 0 33.655 W 80 10.63 .0295 0 VNFI N-UP 3 47 S-E 30140 .0221 .0547 .131 .005 -3.5644
68 233000 51 29.484 N 0 33.687 W 80 10.63 .0295 0 FIX  UPDA 3 40 S-W 30130 .0083 .0173 0 .0044 -4.3555
68 233000 51 29.485 N 0 33.742 W 80 10.63 .0295 0 VNFI N-UP 3 40 S-W 30130 .0179 .0728 .2051 .0034 -4.209
69 5800 51 29.474 N 0 33.661 W 80 10.63 .0295 0 FIX  UPDA 3 40 S-W 30140 .0063 .0128 0 .0054 -3.3203
69 5800 51 29.471 N 0 33.645 W 80 10.63 .0295 0 VNFI N-UP 3 40 S-W 30140 .0237 .0582 .1448 .0048 -3.3105
69 11400 51 29.813 N 0 33.708 W 80 10.63 .0295 0 FIX  N-UP 3 8.2 S-W 30130 .1108 .0519 0 .0039 -7.8907
69 13100 51 29.471 N 0 33.799 W 80 10.63 .0295 0 FIX  UPDA 3 59 S-E 30120 .0029 .0092 0 .0031 -3.1152
69 13100 51 29.469 N 0 33.727 W 80 10.63 .0295 0 VNFI N-UP 3 59 S-E 30120 .0047 .0255 .0533 .0019 -3.0176
69 24300 51 29.31 N 0 33.909 W 80 10.63 .0295 0 FIX  N-UP 3 8.2 S-W 30140 .0542 .072 0 .0036 -.24414
69 31600 51 29.469 N 0 33.641 W 80 10.63 .0295 0 FIX  UPDA 3 31 S-W 30120 .003 .0049 0 .0021 -3.1347
69 31600 51 29.465 N 0 33.623 W 80 10.63 .0295 0 VNFI N-UP 3 31 S-W 30120 .0157 .0328 .0918 .0021 -3.1152
69 33700 51 29.485 N 0 33.755 W 80 10.63 .0295 0 FIX  UPDA 3 21 N-E 30190 .0124 .0153 0 .0043 -3.4765
69 33700 51 29.464 N 0 33.875 W 80 10.63 .0295 0 VNFI N-UP 3 21 N-E 30190 .0215 .1857 .5239 .0042 -3.4668
69 50100 51 29.403 N 0 33.643 W 80 10.63 .0295 0 FIX  N-UP 3 5.4 S-W 30120 .0844 .1057 0 .0048 -2.7246
69 52300 51 29.468 N 0 34.68 W 80 10.63 .0295 0 FIX  N-UP 3 84 N-E 30190 .013 .3047 0 .0057 -3.457
69 52300 51 29.474 N 0 34.48 W 80 10.63 .0295 0 VNFI N-UP 2 84 N-E 30190 .0171 .5019 .0469 .0062 -3.4375
69 55300 51 30.582 N 0 34.415 W 80 10.63 .0295 0 FIX  N-UP 3 8.3 S-E 30200 .4012 .4256 0 .0207 -19.687
69 71000 51 29.497 N 0 33.67 W 80 10.63 .0295 0 FIX  UPDA 3 22 N-W 30190 .0069 .0079 0 .0029 -3.418
69 71000 51 29.512 N 0 33.824 W 80 10.63 .0295 0 VNFI N-UP 3 22 N-W 30190 .0228 .1 .2734 .0028 -3.4961
69 74100 51 29.494 N 0 33.787 W 80 10.63 .0295 0 FIX  UPDA 3 40 S-E 30200 .0093 .018 0 .0082 -4.1797
69 74100 51 29.508 N 0 33.617 W 80 10.63 .0295 0 VNFI N-UP 3 40 S-E 30200 .0367 .0785 .1959 .0063 -4.1992
69 80400 51 29.586 N 0 34.007 W 80 10.63 .0295 0 FIX  UPDA 3 10 N-E 30130 .0212 .0421 0 .002 -1.2011
69 92600 51 29.476 N 0 33.597 W 80 10.63 0 0 FIX  UPDA 3 49 S-W 30200 .0072 .019 0 .0072 -4.1504
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69 92600 51 29.493 N 0 33.748 W 80 10.63 0 0 VNFI N-UP 3 49 S-W 30200 .0277 .0655 .1385 .006 -4.1504
69 94900 51 29.473 N 0 33.799 W 80 10.63 0 0 FIX  UPDA 3 50 N-E 30130 .0068 .0193 0 .007 -3.9844
69 94900 51 29.489 N 0 33.677 W 80 10.63 0 0 VNFI N-UP 3 50 N-E 30130 .0108 .0569 .1222 .0056 -3.8672
69 111000 51 27.572 N 0 26.531 W 80 10.63 20 0 FIX  UPDA 4 11 S-W 30200 .1156 .1489 0 .0103 -3.8965
69 113600 51 30.294 N 0 41.038 W 80 10.63 20 0 FIX  N-UP 3 37 N-W 30130 .2727 .4891 0 .2273 -3.8086
69 113600 51 29.704 N 0 33.712 W 80 10.63 20 -19 VNFI N-UP 3 37 N-W 30130 .0365 .1665 .455 .0121 -3.0566
69 193800 51 29.46 N 0 33.733 W 80 0 0 0 FIX  UPDA 3 38 N-E 30200 .0081 .0162 0 .0069 -5.752
69 193800 51 29.482 N 0 33.599 W 80 0 0 0 VNFI N-UP 3 38 N-E 30200 .0139 .0644 .1687 .0054 -5.7129
69 200000 51 29.474 N 0 33.685 W 80 0 0 0 FIX  N-UP 3 8.4 S-W 30190 .0213 .03 0 .0018 -5.1953
69 202900 51 29.462 N 0 33.623 W 80 0 0 0 FIX  UPDA 3 32 S-W 30180 .0059 .0098 0 .0042 -5.2246
69 202900 51 29.468 N 0 33.691 W 80 0 0 0 VNFI N-UP 3 32 S-W 30180 .0232 .0473 .1331 .0029 -5.166
69 205400 51 29.481 N 0 33.751 W 80 0 0 0 FIX  UPDA 3 25 S-E 30130 .0101 .0127 0 .0052 -5.9082
69 205400 51 29.479 N 0 33.776 W 80 0 0 0 VNFI N-UP 3 25 S-E 30130 .065 .134 .382 .0052 -5.957
69 212300 51 29.477 N 0 33.632 W 80 0 0 0 FIX  UPDA 3 48 N-W 30200 .0064 .0156 0 .0069 -5.4199
69 212300 51 29.488 N 0 33.775 W 80 0 0 0 VNFI N-UP 3 48 N-W 30200 .0108 .0458 .1099 .0045 -5.3906
69 221300 51 29.385 N 0 33.717 W 80 0 0 0 FIX  N-UP 3 5.5 S-W 30180 .0418 .0715 0 .0032 -3.7793
69 224100 51 29.47 N 0 33.517 W 80 0 0 0 FIX  N-UP 3 74 S-W 30130 .0081 .063 0 .01 -5.6934
69 231000 51 29.453 N 0 33.753 W 80 0 0 0 FIX  UPDA 3 10 N-W 30200 .0197 .0212 0 .0013 -5.9863
70 700 51 29.483 N 0 33.503 W 80 0 0 0 FIX  N-UP 3 76 S-W 30140 .0059 .0559 0 .0074 -4.9609
70 700 51 29.494 N 0 33.762 W 80 0 0 0 VNFI N-UP 2 76 S-W 30140 .0141 .107 .073 .0053 -4.9902
70 2700 51 29.49 N 0 33.671 W 80 0 0 0 FIX  UPDA 3 17 S-W 30130 .0196 .0231 0 .0057 -5.6543
70 15200 51 29.516 N 0 33.658 W 80 0 0 0 FIX  UPDA 3 17 S-W 30140 .0129 .0156 0 .0035 -5.2637
70 22200 51 29.473 N 0 33.64 W 80 0 0 0 FIX  UPDA 3 64 S-W 30120 .0025 .0113 0 .003 -5.752
70 22200 51 29.477 N 0 33.677 W 80 0 0 0 VNFI N-UP 3 64 S-W 30120 .0111 .0356 .0553 .0028 -5.8008
70 25000 51 29.549 N 0 33.793 W 80 0 0 0 FIX  UPDA 3 10 N-E 30190 .0253 .0284 0 .0017 -3.8769
70 40700 51 29.458 N 0 33.725 W 80 0 0 0 FIX  UPDA 3 14 S-W 30120 .0195 .0292 0 .0032 -5.3906
70 43500 51 29.473 N 0 33.719 W 80 0 0 0 FIX  UPDA 3 48 N-E 30190 .0049 .0124 0 .0048 -5.166
70 43500 51 29.475 N 0 33.688 W 80 0 0 0 VNFI N-UP 3 48 N-E 30190 .0112 .0484 .1017 .0046 -5.1953
70 50300 51 29.492 N 0 33.752 W 80 0 0 0 FIX  UPDA 3 13 N-E 30180 .015 .0167 0 .002 -4.5508
70 62200 51 29.501 N 0 33.678 W 80 0 0 0 FIX  UPDA 3 41 N-W 30190 .0051 .01 0 .0045 -5.1172
70 62200 51 29.496 N 0 33.616 W 80 0 0 0 VNFI N-UP 3 41 N-W 30190 .0134 .0489 .1204 .004 -5.0977
70 64800 51 29.476 N 0 33.764 W 80 0 0 0 FIX  UPDA 3 61 N-E 30180 .0028 .0111 0 .0034 -5.0781
70 64800 51 29.481 N 0 33.692 W 80 0 0 0 VNFI N-UP 3 61 N-E 30180 .0031 .0225 .0382 .0021 -5.0781
70 81000 51 29.525 N 0 33.646 W 80 0 0 0 FIX  N-UP 3 8.2 N-W 30190 .0336 .0336 0 .0018 -4.7852
70 83600 51 29.488 N 0 33.633 W 80 0 0 0 FIX  UPDA 3 28 N-W 30180 .0066 .0093 0 .0041 -5.0586
70 83600 51 29.504 N 0 33.813 W 80 0 0 0 VNFI N-UP 3 28 N-W 30180 .0106 .0476 .143 .0024 -5.0684
```
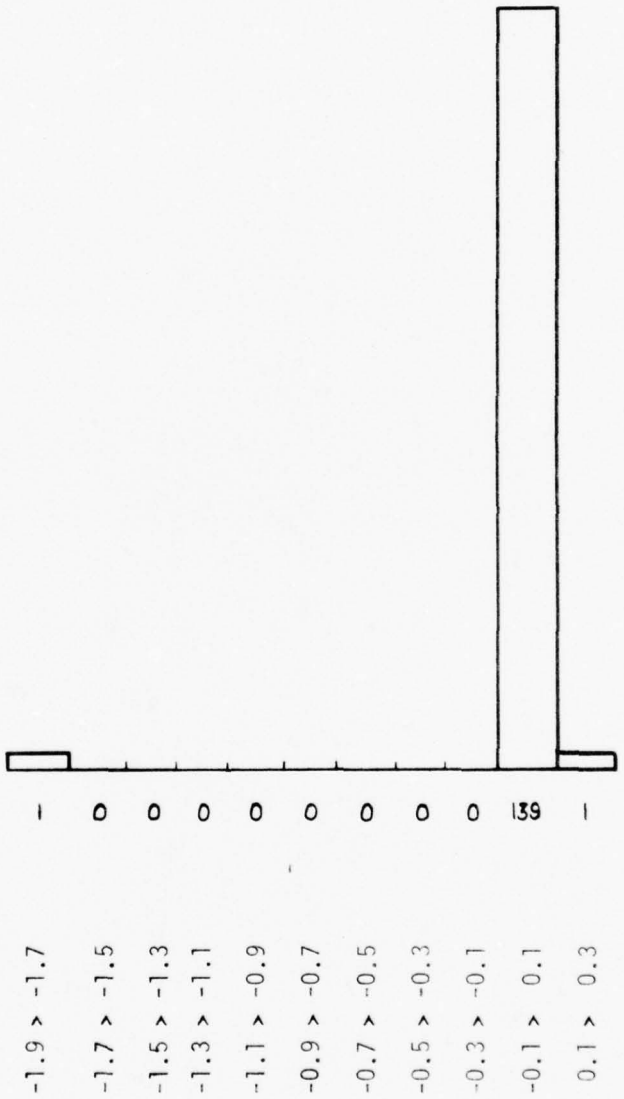
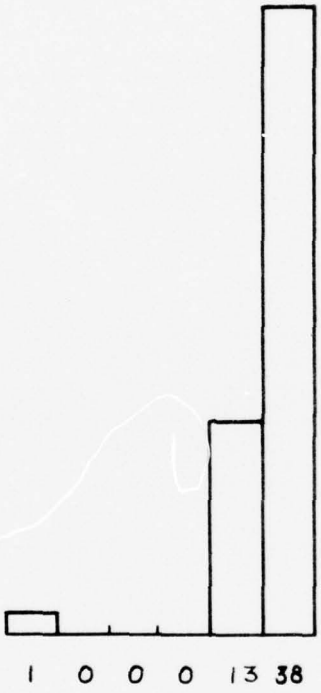

APPENDIX C

LATITUDE ERROR HISTOGRAM BEFORE EDITING
PARTITION FIX : UPDATE

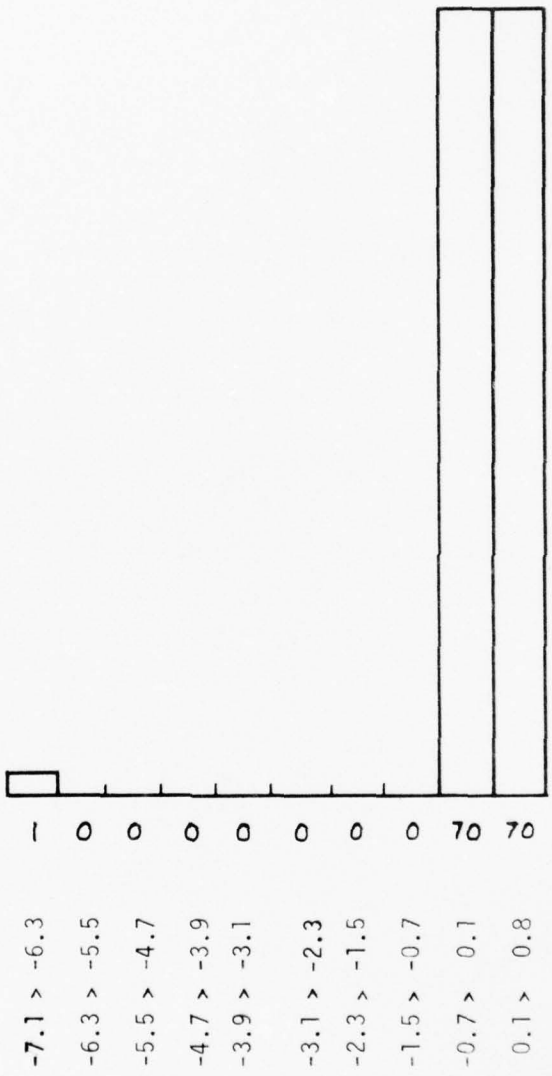


LATITUDE ERROR HISTOGRAM BEFORE EDITING
PARTITION FIX : N-UPDATE

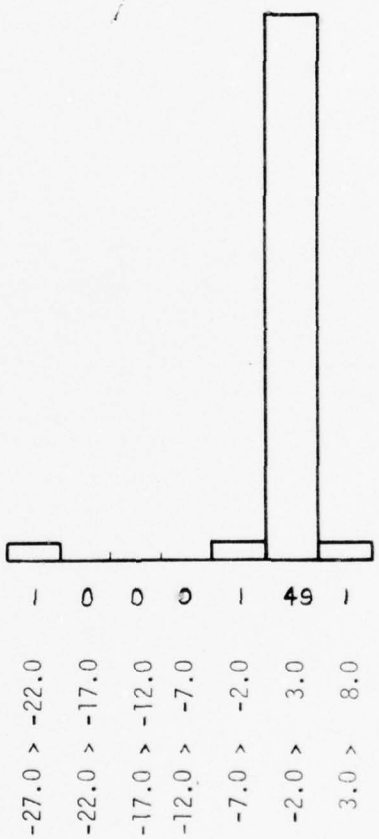


LATITUDE ERROR HISTOGRAM BEFORE EDITING
PARTITION V_N FIX

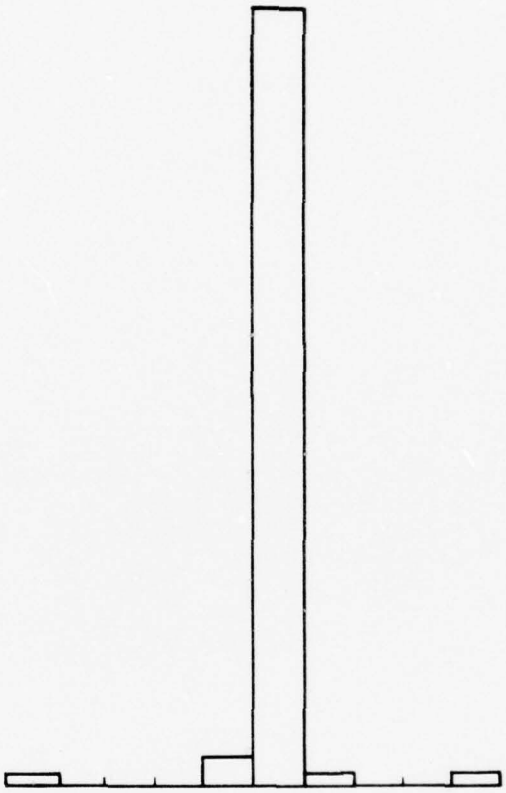
LONGTITUDE ERROR HISTOGRAM BEFORE EDITING
PARTITION FIX : N - UPDATE



LONGTITUDE ERROR HISTOGRAM BEFORE EDITING
PARTITION FIX : N-UPDATE



LONGTITUDE ERROR HISTOGRAM BEFORE EDITING
PARTITION V_N FIX



APPENDIX D: LISTING OF PROGRAM /SAT2

```
*#4141TAJ   /SAT-SY; SATNAV  FRIDAY  JUN 27,  1975  9:34: 44 AM
$ CARD
C     /SAT2 SORTS THE ROUGH DATA FROM FILE /SATDAT-DA
C     INTO FILE /SATR-DA SUCH THAT IT IS SUITABLE FOR
C     REGRESSION WORK.
C
      REAL LATM, LONM
      INTEGER DAY, TIME, SAT, TLAT, TLON, HRS, SATNUM(6)
      DIMENSION DOPPLER (40), CENTRE (40)
DATA ONE /'1'/, ARROW /'^'/, TLAT, TLON /51,0/
      DATA TLATM, TLONM /29.450,33.583/, ZERO /'0'/
DATA SATNUM / 30120, 30130, 30140, 30180, 30190, 30200/
DATA PI /3.141592654/
C     OPEN INPUT AND OUTPUT FILES
      OPEN (1, INPUT, /SATDAT-DA)
      OPEN (2, OUTPUT, /SATR-DA)
C     PRINT PROGRAM NAME
      PRINT ( / 'PROGRAM /SAT2' / 2X, 'SORTS DATA FROM /SATDAT-DA',
     & 'INTO REGRESSION DATA FILE /SATR-DA)
C     SET NUMBER OF RECORDS COUNTER TO ZERO
      ICNT=0
C     CLEAR DOPPLER AND CENTRE ARRAYS
10    DO 11 I=1,40
      DOPPLER (I) = ZERO
11    CENTRE (I) = ZERO
C     READ A RECORD OF TWELVE LINES
          READ TYPE OF FIX
      READ (1,100, END=1000) TFIX
```

```
C       READ DOPPLER DATA
        READ (1,110) DOPPLER
C       READ CENTRE DATA
        READ (1,110) CENTRE
C       READ DAY, TIME LAT LONG
        READ (1,120) DAY, TIME, LAT, LATM, LON, LONM
C       READ ITER ELEY SAT & FREQ
        READ (1,130) ITER, ELEY, SAT, X1, X2, X3, X4, FREQ
C       READ UPDATE
        READ (1,140) UPDATE
C  TEST THAT LAT AND LONG DEGREES ARE CORRECT
        IF (LAT. NE. TLAT. OR. LON. NE. TLON) GOTO 10
C  CALCULATE LAT AND LONG ERRORS IN NAUTICAL MILES
        ELAT = LATM-TLATM
        ELON = (LONM-TLONM) *COS((FLOAT(TLAT)+TLATM/60.) *(PI/180.))
C  CALCULATE NUMBER OF MINUTES AFTER MIDNIGHT
        HRS = TIME/10000
        MINS=TIME/100-HRS*100+HRS*60
C  CALCULATE NUMBER OF DOPPLERS BEFORE AND AFTER
C  CENTRE OF PASS
C     CLEAR CENTRE ARROW REACHED FLAG NARR
C     CLEAR NUMBER OF DOPPLERS BEFORE CENTRE COUNTER NOBC
C     CLEAR NUMBER OF DOPPLERS AFTER CENTRE COUNTER NOAC
      NARR=0
      NOBC=0
      NOAC=0
C  START CALCULATIONS
        DO 20 I=1, 40
```

```
      IF (DOPPLER (I). NE. ONE) GOTO 15
      IF (NARR. EQ. 0) NOBC=NOBC+1
      IF (NARR. EQ. 1) NOAC=NOAC+1
15    IF (CENTRE (I). EQ. ARROW) NARR=1
20    CONTINUE
C     CALCULATE WHICH SATELLITE
      DO 3 I=1, 6
      IF (SAT. EQ. SATNUM (I)) SAT = I
30    CONTINUE
C     CALCULATE THE FADIAL ERROR DISTANCE
      R=SQRT (ELAT*ELAT + ELON *ELON)
C     CALCULATE ANGLE OF POSITION FROM DUE NORTH
C     REMEMBER THAT LONGITUDE IS WESTERLY
        ELON=-ELON
        ANG= 0.
        IF (ELAT.GT.0.001. OR ELAT.LT.-0.001) GOTO 40
        IF (ELON.GT.0.001) ANG=90.
        IF (ELON.LT.0.001) ANG=270.
        GOTO 70
40      IF (ELON.GT.0.001. OR.ELON.LT.-0.001) GOTO 50
        IF (ELAT. LT.0.) ANG=180.
        GOTO 70
C     CALCULATE ATAN ANGLE
50    TANG=ATAN(ELON/ELAT) *(180/PI)
      IF(ELON.LT.0.) GOTO 60
      ANG=TANG
      IF(ELAT.LT.0.) ANG=180.+ TANG
      GOTO 70
```

```
60    ANG=360.+ TANG
      IF (ELAT. LT.0.) ANG=180.+ TANG
70    CONTINUE
      ELON= -ELON
C     WRITE THE DATA TO THE OUTPUT FILE /SATR
      WRITE (2,210) DAY, MINS, ITER, ELEY, FREQ, NOBC, NOAC, TFIX
     &   UPDATE, SAT, ELAT, ELON, R, ANG
C     UPDATE RECORD COUNTER
      ICNT=ICNT+1
C     READ ANOTHER RECORD
      GOTO 10
C
C     LIST OF FORMATS
C
100   FORMAT (/4X,A4)
110   FORMAT (40A1)
120   FORMAT (/3I,F,1X,I,F)
130   FORMAT (/I,F,3X,I,5F)
140   FORMAT (IIIA4)
C
210   FORMAT (3(I,1X), 2(F,1X), 2(I,1X), 2(A4,1X), I, 4(1X,F))
C
C     END OF PROGRAM
C
1000  CLOSE
       PRINT (/, 'END OF PROGRAM',/,5X,
     &   'NUMBER OF RECORDS =  ', I), ICNT
      STOP
      END
```

APPENDIX E: Listing of data file/SATR by partition

PARTITION FIX.UPDATE

#	DAY	MINS	ITER	ELEV	FREQ
2	62.000	988.00	3.0000	15.000	-7.3828
3	62.000	1007.0	3.0000	35.000	-8.0078
5	62.000	1114.0	3.0000	49.000	-6.8848
7	62.000	1146.0	3.0000	52.000	-6.8067
9	62.000	1219.0	3.0000	10.000	-6.6016
10	62.000	1253.0	3.0000	34.000	-6.4063
12	62.000	1275.0	3.0000	22.000	-6.3867
14	62.000	1329.0	3.0000	35.000	-6.0547
19	62.000	1434.0	3.0000	10.000	-5.4785
20	63.000	102.00	3.0000	50.000	-5.3711
22	63.000	153.00	3.0000	15.000	-5.4981
23	63.000	189.00	3.0000	10.000	-6.3086
24	63.000	208.00	3.0000	36.000	-5.1270
26	63.000	294.00	3.0000	44.000	-5.2246
29	63.000	327.00	3.0000	12.000	-5.0977
30	63.000	400.00	3.0000	46.000	-5.1172
32	63.000	433.00	3.0000	58.000	-5.0488
34	63.000	509.00	3.0000	10.000	-5.5664
37	63.000	1097.0	4.0000	27.000	-4.6680
41	63.000	1204.0	3.0000	65.000	-4.3945
43	63.000	1225.0	3.0000	11.000	-4.5605
46	63.000	1310.0	3.0000	14.000	-4.4336
47	63.000	1328.0	3.0000	14.000	-3.4863
48	63.000	1368.0	3.0000	19.000	-4.1992
49	63.000	1436.0	3.0000	65.000	-4.0820
51	64.000	46.000	3.0000	24.000	-3.7598
53	64.000	102.00	3.0000	29.000	-3.9648
58	64.000	246.00	3.0000	24.000	-3.9844
63	64.000	384.00	3.0000	30.000	-3.7695
65	64.000	460.00	3.0000	20.000	-3.8769
67	64.000	478.00	3.0000	39.000	-4.6484
69	64.000	514.00	3.0000	12.000	-3.8965
70	64.000	584.00	3.0000	51.000	-4.8535
73	64.000	721.00	3.0000	65.000	-4.6582
75	64.000	770.00	3.0000	26.000	-4.1992

77	64.000	828.00	3.0000	29.000	-4.2285
79	64.000	876.00	2.0000	68.000	-4.1113
82	64.000	984.00	3.0000	14.000	-3.0762
83	64.000	1017.0	3.0000	45.000	-4.7852
85	64.000	1047.0	3.0000	13.000	-4.4336
86	64.000	1124.0	3.0000	38.000	-5.4981
88	64.000	1155.0	3.0000	66.000	-5.0000
91	64.000	1195.0	3.0000	37.000	-5.1367
94	64.000	1261.0	3.0000	27.000	-4.2090
96	64.000	1284.0	3.0000	29.000	-4.6680
100	64.000	1384.0	3.0000	34.000	-4.3066
103	64.000	1430.0	3.0000	10.000	-3.4570
104	65.000	51.000	3.0000	56.000	-4.0723
106	65.000	98.000	3.0000	53.000	-4.1601
108	65.000	156.00	3.0000	12.000	-4.2578
109	65.000	198.00	3.0000	13.000	-4.4238
110	65.000	304.00	3.0000	55.000	-4.0039
112	65.000	335.00	3.0000	16.000	-4.2285
113	65.000	410.00	3.0000	37.000	-4.1797
117	65.000	517.00	3.0000	70.000	-4.9219
119	65.000	548.00	3.0000	23.000	-4.1894
122	65.000	622.00	3.0000	29.000	-4.9512
124	65.000	670.00	3.0000	33.000	-3.8574
126	65.000	716.00	3.0000	12.000	-2.8613
127	65.000	776.00	3.0000	56.000	-3.9062
129	65.000	821.00	3.0000	58.000	-3.7500
131	65.000	884.00	3.0000	12.000	-2.8222
132	66.000	1133.0	3.0000	29.000	-3.9551
138	66.000	1269.0	3.0000	21.000	-3.6621
140	66.000	1294.0	3.0000	36.000	-4.0820
142	66.000	1379.0	3.0000	14.000	-3.2715
143	66.000	1400.0	3.0000	51.000	-4.1113
145	66.000	1426.0	3.0000	11.000	-3.2226
146	67.000	55.000	3.0000	47.000	-3.6328
148	67.000	94.000	3.0000	56.000	-3.3203
150	67.000	160.00	3.0000	10.000	-3.6523
151	67.000	200.00	3.0000	33.000	-3.5547
156	67.000	344.00	3.0000	20.000	-3.4180
158	67.000	382.00	3.0000	12.000	-4.1699
159	67.000	420.00	3.0000	29.000	-3.8672

163	67.000	489.00	3.0000	53.000	-4.4043
165	67.000	557.00	3.0000	18.000	-3.3984
166	67.000	580.00	3.0000	39.000	-4.0332
170	67.000	673.00	3.0000	39.000	-3.4082
173	67.000	712.00	3.0000	13.000	-1.9238
174	67.000	780.00	3.0000	47.000	-3.7207
176	67.000	818.00	3.0000	61.000	-3.5449
178	67.000	888.00	3.0000	10.000	-3.8672
179	67.000	924.00	3.0000	29.000	-3.4375
181	67.000	978.00	3.0000	29.000	-3.6914
184	67.000	1085.0	3.0000	56.000	-3.8281
186	67.000	1102.0	3.0000	11.000	-4.2383
189	67.000	1190.0	3.0000	11.000	-3.8867
190	67.000	1205.0	3.0000	51.000	-4.3066
194	67.000	1244.0	3.0000	19.000	-4.2871
195	67.000	1311.0	3.0000	35.000	-4.1601
197	67.000	1336.0	3.0000	21.000	.00000
203	68.000	18.000	3.0000	21.000	-4.8730
205	68.000	39.000	3.0000	27.000	-4.3848
207	68.000	109.00	3.0000	21.000	-3.7793
209	68.000	146.00	3.0000	68.000	-4.5801
211	68.000	251.00	3.0000	15.000	-4.6777
215	68.000	372.00	3.0000	52.000	-3.4473
217	68.000	400.00	3.0000	48.000	-3.2910
219	68.000	422.00	3.0000	22.000	-4.2187
221	68.000	480.00	3.0000	11.000	-3.2422
222	68.000	507.00	3.0000	35.000	-3.2031
226	68.000	622.00	3.0000	21.000	-3.1250
232	68.000	746.00	3.0000	20.000	-4.2773
234	68.000	763.00	3.0000	30.000	-3.6523
236	68.000	836.00	3.0000	21.000	-3.0664
238	68.000	869.00	3.0000	61.000	-3.4863
240	68.000	928.00	3.0000	15.000	-3.1330
241	68.000	976.00	3.0000	12.000	-2.7441
244	68.000	1064.0	3.0000	22.000	-4.5312
246	68.000	1140.0	3.0000	21.000	-3.8965
253	68.000	1277.0	3.0000	17.000	-4.4824
254	68.000	1303.0	3.0000	47.000	-4.1699
256	68.000	1350.0	3.0000	19.000	-3.6328
257	68.000	1392.0	3.0000	47.000	-3.5840

259	68.000	1410.0	3.0000	40.000	-4.3555
261	69.000	58.000	3.0000	40.000	-3.3203
264	69.000	91.000	3.0000	59.000	-3.1152
267	69.000	196.00	3.0000	31.000	-3.1347
269	69.000	217.00	3.0000	21.000	-3.4765
275	69.000	430.00	3.0000	22.000	-3.4180
277	69.000	461.00	3.0000	40.000	-4.1797
279	69.000	484.00	3.0000	10.000	-1.2011
280	69.000	566.00	3.0000	49.000	-4.1504
282	69.000	589.00	3.0000	50.000	-3.9844
287	69.000	1178.0	3.0000	38.000	-5.7520
290	69.000	1229.0	3.0000	32.000	-5.2246
292	69.000	1254.0	3.0000	25.000	-5.9082
294	69.000	1283.0	3.0000	48.000	-5.4199
298	69.000	1390.0	3.0000	10.000	-5.9863
301	70.000	27.000	3.0000	17.000	-5.6543
302	70.000	112.00	3.0000	17.000	-5.2637
303	70.000	142.00	3.0000	64.000	-5.7520
305	70.000	170.00	3.0000	10.000	-3.8769
306	70.000	247.00	3.0000	14.000	-5.3906
307	70.000	275.00	3.0000	48.000	-5.1660
309	70.000	303.00	3.0000	13.000	-4.5508
310	70.000	382.00	3.0000	41.000	-5.1172
312	70.000	408.00	3.0000	61.000	-5.0781
315	70.000	516.00	3.0000	28.000	-5.0586

PARTITION FIX,NOUPDATE

#	DAY	MINS	ITER	ELEY	FREQ
1	62.000	933.00	4.0000	6.1000	-10.410
16	62.000	1358.0	3.0000	5.9000	-5.1465
28	63.000	312.00	3.0000	7.1000	-4.5410
35	63.000	1066.0	6.0000	84.000	-4.9707
39	63.000	1172.0	3.0000	20.000	-4.9316
44	63.000	1262.0	3.0000	86.000	-4.5117
55	64.000	153.00	3.0000	75.000	-3.8965
57	64.000	206.00	3.0000	4.8000	-5.2148
60	64.000	352.00	3.0000	83.000	-3.5547
62	64.000	371.00	3.0000	7.9000	-6.1035

72	64.000	616.00	3.0000	14.000	-3.7891
81	64.000	908.00	3.0000	8.4000	-5.2344
90	64.000	1174.0	3.0000	4.2000	-3.6426
93	64.000	1228.0	3.0000	7.3000	-9.4336
98	64.000	1300.0	3.0000	48.000	-4.7656
102	64.000	1408.0	3.0000	9.9000	-3.4765
115	65.000	441.00	3.0000	74.000	-3.9648
121	65.000	565.00	3.0000	6.2000	-3.9258
134	66.000	1163.0	3.0000	83.000	-3.9453
136	66.000	1184.0	3.0000	6.7000	-3.2324
137	66.000	1238.0	3.0000	4.6000	-5.8106
153	67.000	304.00	3.0000	6.0000	-3.1445
154	67.000	314.00	3.0000	68.000	-3.5156
161	67.000	449.00	3.0000	84.000	-3.5156
168	67.000	596.00	3.0000	34.000	-5.0684
172	67.000	698.00	3.0000	8.3000	-3.1738
183	67.000	1005.0	3.0000	8.1000	-3.8183
187	67.000	1114.0	3.0000	43.000	-4.1113
192	67.000	1222.0	3.0000	37.000	-4.3262
199	67.000	1352.0	3.0000	84.000	-.58980
201	67.000	1443.0	3.0000	85.000	-3.7012
212	68.000	265.00	3.0000	38.000	-3.8769
214	68.000	295.00	3.0000	9.9000	-2.5976
224	68.000	528.00	3.0000	86.000	-4.1894
228	68.000	638.00	3.0000	85.000	-3.9746
230	68.000	728.00	3.0000	86.000	-3.4180
242	68.000	1037.0	3.0000	75.000	-3.9258
248	68.000	1172.0	3.0000	78.000	-4.3066
250	68.000	1194.0	3.0000	9.7000	-3.6914
251	68.000	1244.0	3.0000	85.000	-3.9258
263	69.000	74.000	3.0000	8.2000	-7.8907
266	69.000	163.00	3.0000	8.2000	-.24414
271	69.000	301.00	3.0000	5.4000	-2.7246
272	69.000	323.00	3.0000	84.000	-3.4570
274	69.000	353.00	3.0000	8.3000	-19.687
285	69.000	696.00	3.0000	37.000	-3.8086
289	69.000	1200.0	3.0000	8.4000	-5.1953
296	69.000	1333.0	3.0000	5.5000	-3.7793
297	69.000	1361.0	3.0000	74.000	-5.6934
299	70.000	7.0000	3.0000	76.000	-4.9609

314	70.000	490.00	3.0000	8.2000	-4.7852

PARTITION VNFIX

#	DAY	MINS	ITER	ELEY	FREQ
4	62.000	1007.0	3.0000	35.000	-8.0078
6	62.000	1114.0	3.0000	49.000	-6.9336
8	62.000	1146.0	3.0000	52.000	-6.7969
11	62.000	1253.0	3.0000	34.000	-6.3379
13	62.000	1275.0	3.0000	22.000	-6.3770
15	62.000	1329.0	3.0000	35.000	-5.9863
21	63.000	102.00	3.0000	50.000	-5.3906
25	63.000	208.00	3.0000	36.000	-5.1270
27	63.000	294.00	3.0000	44.000	-5.2441
31	63.000	400.00	3.0000	46.000	-5.0586
33	63.000	433.00	3.0000	58.000	-5.0293
36	63.000	1066.0	3.0000	84.000	-4.9707
38	63.000	1097.0	5.0000	27.000	-4.6777
40	63.000	1172.0	2.0000	20.000	-4.5898
42	63.000	1204.0	3.0000	65.000	-4.4238
45	63.000	1262.0	2.0000	86.000	-4.5312
50	63.000	1436.0	3.0000	65.000	-4.0820
52	64.000	46.000	3.0000	24.000	-3.7695
54	64.000	102.00	3.0000	29.000	-3.9844
56	64.000	153.00	3.0000	75.000	-3.8867
59	64.000	246.00	3.0000	24.000	-3.9648
61	64.000	352.00	2.0000	83.000	-3.4375
64	64.000	384.00	3.0000	30.000	-3.7402
66	64.000	460.00	3.0000	20.000	-3.9648
68	64.000	478.00	3.0000	39.000	-4.7363
71	64.000	584.00	3.0000	51.000	-4.8730
74	64.000	721.00	3.0000	65.000	-4.6484
76	64.000	770.00	3.0000	26.000	-4.1309
78	64.000	828.00	3.0000	29.000	-4.0625
80	64.000	876.00	3.0000	68.000	-4.0332
84	64.000	1017.0	3.0000	45.000	-4.8242
87	64.000	1124.0	3.0000	38.000	-5.4785
89	64.000	1155.0	3.0000	66.000	-4.9805
92	64.000	1195.0	3.0000	37.000	-5.1074

95	64.000	1261.0	3.0000	27.000	-4.1699
97	64.000	1284.0	3.0000	29.000	-4.6875
99	64.000	1300.0	2.0000	48.000	-4.9512
101	64.000	1384.0	3.0000	34.000	-4.1992
105	65.000	51.000	3.0000	56.000	-4.1211
107	65.000	98.000	3.0000	53.000	-4.1601
111	65.000	304.00	3.0000	55.000	-3.9844
114	65.000	410.00	3.0000	37.000	-4.1894
116	65.000	441.00	3.0000	74.000	-3.9746
118	65.000	517.00	3.0000	70.000	-4.9609
120	65.000	548.00	3.0000	23.000	-4.1309
123	65.000	622.00	3.0000	29.000	-4.9609
125	65.000	670.00	3.0000	33.000	-3.7793
128	65.000	776.00	3.0000	56.000	-3.9160
130	65.000	821.00	3.0000	58.000	-3.7500
133	66.000	1133.0	3.0000	29.000	-4.0234
135	66.000	1163.0	3.0000	83.000	-3.9160
139	66.000	1269.0	3.0000	21.000	-3.7793
141	66.000	1294.0	3.0000	36.000	-4.1016
144	66.000	1400.0	3.0000	51.000	-4.1309
147	67.000	55.000	3.0000	47.000	-3.5840
149	67.000	94.000	3.0000	56.000	-3.3398
152	67.000	200.00	3.0000	33.000	-3.5449
155	67.000	314.00	2.0000	67.000	-7.2168
157	67.000	344.00	3.0000	20.000	-3.4570
160	67.000	420.00	3.0000	29.000	-3.8672
162	67.000	449.00	3.0000	84.000	-3.5742
164	67.000	489.00	3.0000	53.000	-4.3945
167	67.000	580.00	3.0000	39.000	-3.8965
169	67.000	596.00	2.0000	34.000	-34.648
171	67.000	673.00	3.0000	39.000	-3.2812
175	67.000	780.00	3.0000	47.000	-3.4765
177	67.000	818.00	3.0000	61.000	-3.4668
180	67.000	924.00	3.0000	29.000	-3.3496
182	67.000	978.00	3.0000	29.000	-3.7598
185	67.000	1085.0	3.0000	56.000	-3.8672
188	67.000	1114.0	2.0000	43.000	-6.6797
191	67.000	1205.0	3.0000	51.000	-4.0039
193	67.000	1222.0	2.0000	38.000	38.652
196	67.000	1311.0	3.0000	35.000	-4.2090

198	67.000	1336.0	3.0000	21.000	-3.6621
200	67.000	1352.0	2.0000	84.000	-5.1074
202	67.000	1443.0	2.0000	85.000	-3.5449
204	68.000	18.000	3.0000	21.000	-4.8926
206	68.000	39.000	3.0000	27.000	-4.2969
208	68.000	109.00	3.0000	21.000	-3.7988
210	68.000	146.00	3.0000	68.000	-4.6289
213	68.000	265.00	2.0000	38.000	-1.3183
216	68.000	372.00	3.0000	52.000	-3.4473
218	68.000	400.00	3.0000	48.000	-3.2519
220	68.000	422.00	2.0000	22.000	-3.9941
223	68.000	507.00	3.0000	35.000	-3.1445
225	68.000	528.00	3.0000	86.000	-4.1309
227	68.000	622.00	3.0000	21.000	-3.0371
231	68.000	728.00	2.0000	86.000	-3.3691
233	68.000	746.00	3.0000	20.000	-4.3066
235	68.000	763.00	3.0000	30.000	-3.3398
237	68.000	836.00	3.0000	21.000	-3.0957
239	68.000	869.00	3.0000	61.000	-3.3105
243	68.000	1037.0	3.0000	75.000	-3.9746
245	68.000	1064.0	3.0000	22.000	-4.5312
247	68.000	1140.0	3.0000	21.000	-3.8672
249	68.000	1172.0	2.0000	78.000	-4.3262
252	68.000	1244.0	2.0000	85.000	-3.9258
255	68.000	1303.0	3.0000	47.000	-4.1797
258	68.000	1392.0	3.0000	47.000	-3.5644
260	68.000	1410.0	3.0000	40.000	-4.2090
262	69.000	58.000	3.0000	40.000	-3.3105
265	69.000	91.000	3.0000	59.000	-3.0176
268	69.000	196.00	3.0000	31.000	-3.1152
270	69.000	217.00	3.0000	21.000	-3.4668
273	69.000	323.00	2.0000	84.000	-3.4375
276	69.000	430.00	3.0000	22.000	-3.4961
278	69.000	461.00	3.0000	40.000	-4.1992
281	69.000	566.00	3.0000	49.000	-4.1504
283	69.000	589.00	3.0000	50.000	-3.8672
286	69.000	696.00	3.0000	37.000	-3.0566
288	69.000	1178.0	3.0000	38.000	-5.7129
291	69.000	1229.0	3.0000	32.000	-5.1660
293	69.000	1254.0	3.0000	25.000	-5.9570

295	69.000	1283.0	3.0000	48.000	-5.3906
300	70.000	7.0000	2.0000	76.000	-4.9902
304	70.000	142.00	3.0000	64.000	-5.8008
308	70.000	275.00	3.0000	48.000	-5.1953
311	70.000	382.00	3.0000	41.000	-5.0977
313	70.000	408.00	3.0000	61.000	-5.0781
316	70.000	516.00	3.0000	28.000	-5.0684

PARTITION FIX.UPDATE

#	NOBC	NOAC	TFIX	UPDATE	SAT	ELAT	ELON
2	10.000	10.000	FIX	UPDA	1	3.30048E-02	-.24892E-02
3	14.000	15.000	FIX	UPDA	5	1.80054E-02	.13823
5	16.000	16.000	FIX	UPDA	5	9.00269E-03	-.67864E-01
7	17.000	17.000	FIX	UPDA	4	1.80054E-02	.20547
9	7.0000	7.0000	FIX	UPDA	5	3.30048E-02	4.35893E-02
10	15.000	16.000	FIX	UPDA	4	7.99561E-03	-.23030E-01
12	15.000	13.000	FIX	UPDA	2	1.49994E-02	.11893
14	16.000	16.000	FIX	UPDA	6	1.60065E-02	-.16180E-01
19	7.0000	7.0000	FIX	UPDA	1	9.00269E-03	.11332
20	17.000	16.000	FIX	UPDA	1	1.80054E-02	.19551
22	11.000	11.000	FIX	UPDA	3	2.20032E-02	9.34871E-03
23	7.0000	7.0000	FIX	UPDA	5	-.59998E-01	5.79069E-02
24	16.000	16.000	FIX	UPDA	1	1.99890E-03	-.31751E-01
26	19.000	16.000	FIX	UPDA	5	3.00598E-03	.16375
29	9.0000	9.0000	FIX	UPDA	4	5.99670E-03	.12515
30	16.000	20.000	FIX	UPDA	5	2.40021E-02	-.32996E-01
32	17.000	16.000	FIX	UPDA	4	-.99182E-03	.26587
34	8.0000	8.0000	FIX	UPDA	5	-.17990E-01	4.48339E-02
37	15.000	15.000	FIX	UPDA	4	3.10059E-02	7.53407E-02
41	16.000	17.000	FIX	UPDA	4	2.99988E-02	3.11339E-02
43	9.0000	9.0000	FIX	UPDA	2	2.90070E-02	7.47232E-02
46	10.000	10.000	FIX	UPDA	4	4.49982E-02	5.16840E-02
47	11.000	11.000	FIX	UPDA	3	-.26001E-01	5.10569E-02
48	11.000	13.000	FIX	UPDA	6	1.60065E-02	4.48339E-02
49	18.000	18.000	FIX	UPDA	3	1.40076E-02	.11021
51	15.000	14.000	FIX	UPDA	1	4.00085E-02	5.97786E-02
53	16.000	14.000	FIX	UPDA	3	1.00098E-02	6.16502E-02
58	16.000	15.000	FIX	UPDA	5	2.90070E-02	7.78300E-02

63	6.0000	14.000	FIX	UPDA	4	9.00269E-03	9.02854E-02
65	14.000	14.000	FIX	UPDA	5	2.40021E-02	4.60785E-02
67	12.000	17.000	FIX	UPDA	6	4.40063E-02	9.21569E-02
69	7.0000	9.0000	FIX	UPDA	2	2.50092E-02	.15317
70	17.000	17.000	FIX	UPDA	6	2.60010E-02	1.30825E-02
73	5.0000	18.000	FIX	UPDA	3	2.99988E-02	.15878
75	14.000	14.000	FIX	UPDA	1	2.00043E-02	.13139
77	15.000	16.000	FIX	UPDA	3	4.29993E-02	1.05933E-02
79	13.000	18.000	FIX	UPDA	1	3.10059E-02	-.99568E-02
82	10.000	11.000	FIX	UPDA	1	8.39996E-02	6.28948E-02
83	17.000	15.000	FIX	UPDA	5	3.80096E-02	.10896
85	11.000	10.000	FIX	UPDA	4	2.30103E-02	5.04394E-02
86	15.000	15.000	FIX	UPDA	5	3.59955E-02	5.29286E-02
88	16.000	17.000	FIX	UPDA	4	2.30103E-02	.10835
91	15.000	16.000	FIX	UPDA	6	1.20087E-02	6.22678E-02
94	14.000	14.000	FIX	UPDA	4	-.49896E-02	4.79502E-02
96	16.000	15.000	FIX	UPDA	2	1.49994E-02	8.40624E-02
100	15.000	18.000	FIX	UPDA	3	3.70026E-02	7.84570E-02
103	8.0000	7.0000	FIX	UPDA	1	-.15991E-01	6.22678E-02
104	18.000	17.000	FIX	UPDA	3	2.20032E-02	4.73231E-02
106	16.000	18.000	FIX	UPDA	1	3.50037E-02	9.02854E-02
108	10.000	9.0000	FIX	UPDA	3	2.90070E-02	3.30055E-02
109	11.000	10.000	FIX	UPDA	5	3.00598E-03	7.59678E-02
110	19.000	18.000	FIX	UPDA	5	3.30048E-02	7.16069E-02
112	11.000	11.000	FIX	UPDA	4	1.30005E-02	7.34786E-02
113	17.000	17.000	FIX	UPDA	5	2.99988E-02	5.41731E-02
117	19.000	18.000	FIX	UPDA	6	3.90015E-02	.20236
119	12.000	14.000	FIX	UPDA	4	1.80054E-02	2.80271E-02
122	16.000	15.000	FIX	UPDA	6	2.30103E-02	-.61755E-03
124	15.000	16.000	FIX	UPDA	3	2.30103E-02	.11830
126	7.0000	9.0000	FIX	UPDA	1	5.30090E-02	.17621
127	18.000	18.000	FIX	UPDA	3	3.80096E-02	2.36663E-02
129	17.000	17.000	FIX	UPDA	1	2.30103E-02	.14695
131	10.000	9.0000	FIX	UPDA	3	7.00073E-02	-.18621E-02
132	15.000	14.000	FIX	UPDA	5	2.79999E-02	2.11771E-02
138	14.000	8.0000	FIX	UPDA	4	1.20087E-02	4.42164E-02
140	17.000	15.000	FIX	UPDA	2	2.79999E-02	7.90840E-02
142	10.000	11.000	FIX	UPDA	6	5.79987E-02	4.98123E-02
143	17.000	17.000	FIX	UPDA	2	2.00043E-02	4.35893E-02
145	7.0000	10.000	FIX	UPDA	1	-.99182E-03	8.71786E-02

146	18.000	17.000	FIx	UPDA	3	2.90070E-02	5.23110E-02
148	17.000	17.000	FIx	UPDA	1	1.89972E-02	9.40192E-02
150	7.0000	7.0000	FIx	UPDA	3	1.00098E-02	1.93055E-02
151	16.000	16.000	FIx	UPDA	1	1.80054E-02	4.60785E-02
156	13.000	12.000	FIx	UPDA	4	2.90070E-02	8.65515E-02
158	10.000	9.0000	FIx	UPDA	6	1.00098E-02	.11145
159	17.000	17.000	FIx	UPDA	5	1.10016E-02	5.97786E-02
163	17.000	19.000	FIx	UPDA	6	3.50037E-02	.15255
165	9.0000	12.000	FIx	UPDA	4	3.59955E-02	3.79839E-02
166	15.000	17.000	FIx	UPDA	2	3.30048E-02	.10959
170	14.000	16.000	FIx	UPDA	3	3.50037E-02	.10959
173	7.0000	10.000	FIx	UPDA	1	7.40051E-02	.18119
174	14.000	18.000	FIx	UPDA	3	4.00085E-02	4.04731E-02
176	15.000	17.000	FIx	UPDA	1	1.40076E-02	.15068
178	7.0000	8.0000	FIx	UPDA	3	2.00043E-02	5.97786E-02
179	14.000	24.000	FIx	UPDA	1	2.70081E-02	2.55285E-02
181	16.000	14.000	FIx	UPDA	5	2.30103E-02	.10896
184	16.000	17.000	FIx	UPDA	5	2.50092E-02	4.98788E-03
186	5.0000	9.0000	FIx	UPDA	6	3.00598E-03	.10087
189	8.0000	8.0000	FIx	UPDA	5	1.60065E-02	3.67393E-02
190	9.0000	18.000	FIx	UPDA	6	1.49994E-02	9.27746E-02
194	14.000	13.000	FIx	UPDA	2	7.99561E-03	8.77962E-02
195	14.000	17.000	FIx	UPDA	6	2.50092E-02	6.03961E-02
197	14.000	14.000	FIx	UPDA	3	1.69983E-02	9.15300E-02
203	5.0000	14.000	FIx	UPDA	2	3.90015E-02	4.60785E-02
205	14.000	15.000	FIx	UPDA	1	2.90070E-02	8.90408E-02
207	14.000	13.000	FIx	UPDA	3	3.30048E-02	3.36231E-02
209	18.000	17.000	FIx	UPDA	1	3.39966E-02	2.36663E-02
211	10.000	12.000	FIx	UPDA	1	2.40021E-02	1.93055E-02
215	19.000	18.000	FIx	UPDA	5	4.00085E-02	6.41394E-02
217	17.000	16.000	FIx	UPDA	4	2.40021E-02	.10835
219	14.000	14.000	FIx	UPDA	6	3.59955E-02	.10647
221	7.0000	11.000	FIx	UPDA	5	4.20074E-02	3.86110E-02
222	14.000	17.000	FIx	UPDA	4	4.20074E-02	3.92285E-02
226	11.000	14.000	FIx	UPDA	3	2.90070E-02	.12391
232	13.000	14.000	FIx	UPDA	2	1.00708E-03	4.29623E-02
234	8.0000	15.000	FIx	UPDA	1	-.59967E-02	9.65179E-02
236	14.000	14.000	FIx	UPDA	3	4.00085E-02	2.80271E-02
238	13.000	17.000	FIx	UPDA	1	1.89972E-02	8.09462E-03
240	11.000	11.000	FIx	UPDA	5	7.99561E-03	.11644

241	7.0000	10.000	FIX	UPDA	1	3.80096E-02	8.09462E-03
244	14.000	14.000	FIX	UPDA	4	2.70081E-02	9.15300E-02
246	15.000	12.000	FIX	UPDA	6	2.40021E-02	8.15732E-02
253	12.000	12.000	FIX	UPDA	4	2.90070E-02	4.85677E-02
254	17.000	17.000	FIX	UPDA	2	2.70081E-02	9.46462E-02
256	12.000	14.000	FIX	UPDA	6	2.09961E-02	5.97786E-02
257	17.000	17.000	FIX	UPDA	3	3.70026E-02	.10461
259	8.0000	16.000	FIX	UPDA	2	3.39966E-02	6.47569E-02
261	17.000	15.000	FIX	UPDA	3	2.40021E-02	4.85677E-02
264	13.000	18.000	FIX	UPDA	1	2.09961E-02	.13449
267	15.000	16.000	FIX	UPDA	1	1.89972E-02	3.61218E-02
269	14.000	12.000	FIX	UPDA	5	3.50037E-02	.10710
275	15.000	16.000	FIX	UPDA	5	4.69971E-02	5.41731E-02
277	17.000	7.0000	FIX	UPDA	6	4.40063E-02	.12702
279	6.0000	8.0000	FIX	UPDA	2	.13600	.26401
280	18.000	17.000	FIX	UPDA	6	2.60010E-02	8.72167E-03
282	16.000	18.000	FIX	UPDA	2	2.30103E-02	.13449
287	15.000	6.0000	FIX	UPDA	6	1.00098E-02	9.34016E-02
290	16.000	14.000	FIX	UPDA	4	1.20087E-02	2.49109E-02
292	15.000	15.000	FIX	UPDA	2	3.10059E-02	.10461
294	18.000	16.000	FIX	UPDA	6	2.70081E-02	3.05163E-02
298	7.0000	7.0000	FIX	UPDA	6	3.00598E-03	.10586
301	13.000	12.000	FIX	UPDA	2	4.00085E-02	5.48002E-02
302	12.000	12.000	FIX	UPDA	3	6.60095E-02	4.67056E-02
303	17.000	17.000	FIX	UPDA	1	2.30103E-02	3.54947E-02
305	8.0000	7.0000	FIX	UPDA	5	9.89990E-02	.13076
306	10.000	9.0000	FIX	UPDA	1	7.99561E-03	8.84233E-02
307	20.000	16.000	FIX	UPDA	5	2.30103E-02	8.46800E-02
309	9.0000	9.0000	FIX	UPDA	4	4.20074E-02	.10523
310	18.000	17.000	FIX	UPDA	5	5.10101E-02	5.91515E-02
312	16.000	17.000	FIX	UPDA	4	2.60010E-02	.11271
315	14.000	15.000	FIX	UPDA	4	3.80096E-02	3.11339E-02

PARTITION FIX.NOUPDATE

#	NOBC	NOAC	TFIX	UPDATE	SAT	ELAT	ELON
1	1.0000	2.0000	FIX	N-UP	3	9.40094E-02	2.86447E-02
16	2.0000	1.0000	FIX	N-UP	4	-.58991E-01	6.03961E-02
28	2.0000	1.0000	FIX	N-UP	1	-.99945E-02	6.53840E-02

35	17.000	17.000	FIX	N-UP	5	2.70081E-02	.28019
39	1.0000	12.000	FIX	N-UP	5	4.89960E-02	8.90408E-02
44	14.000	17.000	FIX	N-UP	6	2.79999E-02	-.16064
55	17.000	18.000	FIX	N-UP	1	3.10059E-02	1.80609E-02
57	1.0000	2.0000	FIX	N-UP	3	.11700	1.86879E-02
60	19.000	16.000	FIX	N-UP	5	5.20020E-02	6.22678E-02
62	3.0000	3.0000	FIX	N-UP	6	.11400	.18369
72	1.0000	9.0000	FIX	N-UP	3	6.10046E-02	.11021
81	4.0000	5.0000	FIX	N-UP	5	7.20062E-02	8.46800E-02
90	1.0000	2.0000	FIX	N-UP	2	-.12599	8.21908E-02
93	1.0000	2.0000	FIX	N-UP	5	.17601	-.29139
98	2.0000	17.000	FIX	N-UP	6	2.20032E-02	5.60448E-02
102	7.0000	7.0000	FIX	N-UP	6	7.00073E-02	-.12446E-01
115	18.000	16.000	FIX	N-UP	4	2.50092E-02	.18119
121	2.0000	1.0000	FIX	N-UP	3	-.18997E-01	.13076
134	13.000	16.000	FIX	N-UP	4	3.50037E-02	.31817
136	2.0000	1.0000	FIX	N-UP	2	-.57999E-01	6.97448E-02
137	1.0000	2.0000	FIX	N-UP	5	.13600	-.36112E-01
153	1.0000	2.0000	FIX	N-UP	1	-.13992E-01	5.16840E-02
154	1.0000	16.000	FIX	N-UP	5	-.90027E-02	.19489
161	14.000	15.000	FIX	N-UP	4	4.60052E-02	-.24345
168	1.0000	12.000	FIX	N-UP	6	5.79987E-02	.14321
172	4.0000	4.0000	FIX	N-UP	6	-.43991E-01	9.34016E-02
183	4.0000	3.0000	FIX	N-UP	4	5.90057E-02	6.53840E-02
187	1.0000	16.000	FIX	N-UP	4	4.00085E-02	8.03286E-02
192	1.0000	13.000	FIX	N-UP	4	3.50037E-02	.11955
199	6.0000	18.000	FIX	N-UP	2	2.09961E-02	.24843
201	18.000	17.000	FIX	N-UP	3	5.20020E-02	.96696
212	3.0000	16.000	FIX	N-UP	5	2.20032E-02	4.79502E-02
214	6.0000	6.0000	FIX	N-UP	4	4.60052E-02	.13263
224	15.000	19.000	FIX	N-UP	6	-.84992E-01	-1.9993
228	1.0000	16.000	FIX	N-UP	2	5.20020E-02	-.89535
230	18.000	18.000	FIX	N-UP	3	7.20062E-02	-1.2434
242	18.000	16.000	FIX	N-UP	5	2.90070E-02	.25092
248	17.000	17.000	FIX	N-UP	4	1.00098E-02	-.37974E-01
250	7.0000	6.0000	FIX	N-UP	2	-.19989E-02	6.60015E-02
251	14.000	19.000	FIX	N-UP	6	2.00043E-02	8.72167E-03
263	2.0000	4.0000	FIX	N-UP	2	.36301	7.78300E-02
266	4.0000	3.0000	FIX	N-UP	3	-.14000	.20298
271	2.0000	1.0000	FIX	N-UP	1	-.46997E-01	3.73664E-02

272	17.000	16.000	FIX	N-UP	5	1.80054E-02	.68304
274	4.0000	4.0000	FIX	N-UP	6	1.1320	.51804
285	16.000	17.000	FIX	N-UP	2	.84401	4.6418
289	4.0000	4.0000	FIX	N-UP	5	2.40021E-02	6.35123E-02
296	1.0000	2.0000	FIX	N-UP	4	-.65002E-01	8.34354E-02
297	19.000	17.000	FIX	N-UP	2	2.00043E-02	-.41091E-01
299	19.000	17.000	FIX	N-UP	3	3.30048E-02	-.49803E-01
314	4.0000	3.0000	FIX	N-UP	5	7.49969E-02	3.92285E-02

PARTITION VNFIX

#	NOBC	NOAC	TFIX	UPDATE	SAT	ELAT	ELON
4	14.000	15.000	VNFI	N-UP	5	2.30103E-02	.10398
6	16.000	16.000	VNFI	N-UP	5	1.49994E-02	-.40464E-01
8	17.000	17.000	VNFI	N-UP	4	2.30103E-02	.12702
11	15.000	16.000	VNFI	N-UP	4	2.30103E-02	5.10569E-02
13	15.000	13.000	VNFI	N-UP	2	1.69983E-02	.10772
15	16.000	15.000	VNFI	N-UP	6	3.70026E-02	.10087
21	17.000	16.000	VNFI	N-UP	1	2.60010E-02	8.96679E-02
25	16.000	16.000	VNFI	N-UP	1	1.49994E-02	2.49109E-02
27	19.000	17.000	VNFI	N-UP	5	1.30005E-02	.11395
31	16.000	20.000	VNFI	N-UP	5	3.19977E-02	9.34871E-03
33	17.000	16.000	VNFI	N-UP	4	1.40076E-02	.17123
36	17.000	17.000	VNFI	N-UP	5	.00000	-.47196
38	15.000	15.000	VNFI	N-UP	4	3.39966E-02	5.60448E-02
40	1.0000	12.000	VNFI	N-UP	5	4.00085E-02	.11830
42	16.000	17.000	VNFI	N-UP	4	4.29993E-02	.12889
45	14.000	17.000	VNFI	N-UP	6	9.00269E-03	.22727
50	16.000	18.000	VNFI	N-UP	3	2.40021E-02	-.53546E-01
52	15.000	14.000	VNFI	N-UP	1	3.39966E-02	8.53069E-02
54	16.000	14.000	VNFI	N-UP	3	3.30048E-02	.16002
56	17.000	18.000	VNFI	N-UP	1	4.69971E-02	.17870
59	16.000	15.000	VNFI	N-UP	5	1.00098E-02	.14695
61	19.000	17.000	VNFI	N-UP	5	6.70013E-02	-.30696
64	6.0000	14.000	VNFI	N-UP	4	7.99561E-03	.10087
66	14.000	14.000	VNFI	N-UP	5	4.00085E-02	.13574
68	12.000	17.000	VNFI	N-UP	6	4.29993E-02	.14134
71	17.000	15.000	VNFI	N-UP	6	5.20020E-02	.15006
74	5.0000	18.000	VNFI	N-UP	3	2.99988E-02	.16375

76	14.000	15.000	VNFI	N-UP	1	4.00085E-02	7.09894E-02
78	14.000	16.000	VNFI	N-UP	3	8.20007E-02	.16126
80	13.000	18.000	VNFI	N-UP	1	3.70026E-02	9.83800E-02
84	17.000	15.000	VNFI	N-UP	5	4.60052E-02	4.48339E-02
87	15.000	15.000	VNFI	N-UP	5	4.69971E-02	.10835
89	17.000	17.000	VNFI	N-UP	4	2.30103E-02	.10025
92	15.000	16.000	VNFI	N-UP	6	2.70081E-02	8.09462E-03
95	14.000	14.000	VNFI	N-UP	4	-.49896E-02	.14944
97	16.000	14.000	VNFI	N-UP	2	2.90070E-02	3.42501E-02
99	2.0000	17.000	VNFI	N-UP	6	1.60065E-02	3.54947E-02
101	15.000	17.000	VNFI	N-UP	3	4.00085E-02	9.34871E-03
105	18.000	17.000	VNFI	N-UP	3	3.30048E-02	.12079
107	16.000	18.000	VNFI	N-UP	1	3.90015E-02	4.79502E-02
111	19.000	20.000	VNFI	N-UP	5	3.70026E-02	5.23110E-02
114	17.000	16.000	VNFI	N-UP	5	3.39966E-02	8.90408E-02
116	18.000	16.000	VNFI	N-UP	4	4.49982E-02	-.23657E-01
118	19.000	18.000	VNFI	N-UP	6	4.40063E-02	-.62230E-02
120	11.000	14.000	VNFI	N-UP	4	4.89960E-02	.17060
123	16.000	16.000	VNFI	N-UP	6	6.19965E-02	.16065
125	15.000	15.000	VNFI	N-UP	3	5.70068E-02	-.18051E-01
128	18.000	18.000	VNFI	N-UP	3	4.20074E-02	7.34786E-02
130	18.000	16.000	VNFI	N-UP	1	4.10004E-02	2.30393E-02
133	15.000	14.000	VNFI	N-UP	5	5.00031E-02	9.34016E-02
135	13.000	16.000	VNFI	N-UP	4	1.80054E-02	-.12265
139	13.000	9.0000	VNFI	N-UP	4	2.90070E-02	8.65515E-02
141	17.000	14.000	VNFI	N-UP	2	3.59955E-02	1.43271E-02
144	17.000	23.000	VNFI	N-UP	2	3.70026E-02	.12889
147	18.000	17.000	VNFI	N-UP	3	2.90070E-02	6.97448E-02
149	17.000	17.000	VNFI	N-UP	1	2.00043E-02	7.97015E-02
152	16.000	16.000	VNFI	N-UP	1	2.30103E-02	6.60015E-02
155	1.0000	16.000	VNFI	N-UP	5	-.15500	.62700
157	13.000	12.000	VNFI	N-UP	4	3.59955E-02	5.48002E-02
160	17.000	16.000	VNFI	N-UP	5	7.99561E-03	4.54610E-02
162	15.000	14.000	VNFI	N-UP	4	1.80054E-02	.44146
164	19.000	17.000	VNFI	N-UP	6	4.00085E-02	6.28948E-02
167	16.000	17.000	VNFI	N-UP	2	5.99976E-02	-.24892E-02
169	1.0000	13.000	VNFI	N-UP	6	1.0520	-2.6755
171	14.000	16.000	VNFI	N-UP	3	6.60095E-02	-.17434E-01
175	15.000	17.000	VNFI	N-UP	3	6.19965E-02	.14508
177	15.000	17.000	VNFI	N-UP	1	2.99988E-02	6.35123E-02

180	14.000	16.000	VNFI	N=UP	1	4.89960E-02	.14259
182	16.000	14.000	VNFI	N=UP	5	3.80096E-02	2.49109E-02
185	17.000	16.000	VNFI	N=UP	5	3.90015E-02	8.65515E-02
188	1.0000	16.000	VNFI	N=UP	4	9.30023E-02	.30883
191	9.0000	16.000	VNFI	N=UP	6	4.00085E-02	5.60543E-03
193	1.0000	13.000	VNFI	N=UP	4	-1.2120	3.4737
196	16.000	16.000	VNFI	N=UP	6	3.10059E-02	.10336
198	14.000	14.000	VNFI	N=UP	3	2.79999E-02	5.72894E-02
200	6.0000	18.000	VNFI	N=UP	2	5.50079E-02	.87419
202	18.000	17.000	VNFI	N=UP	3	-.90027E-02	-1.2577
204	5.0000	14.000	VNFI	N=UP	2	3.30048E-02	1.12109E-02
206	15.000	15.000	VNFI	N=UP	1	2.79999E-02	7.59678E-02
208	14.000	13.000	VNFI	N=UP	3	6.60095E-02	.15504
210	17.000	18.000	VNFI	N=UP	1	4.89960E-02	.13200
213	3.0000	16.000	VNFI	N=UP	5	.16200	-.20422
216	19.000	18.000	VNFI	N=UP	5	4.00085E-02	6.97448E-02
218	17.000	16.000	VNFI	N=UP	4	3.59955E-02	4.98123E-02
220	15.000	14.000	VNFI	N=UP	6	4.20074E-02	-.12446E-02
223	14.000	16.000	VNFI	N=UP	4	6.10046E-02	.15940
225	15.000	19.000	VNFI	N=UP	6	5.20020E-02	.27459
227	11.000	14.000	VNFI	N=UP	3	6.19965E-02	8.72167E-03
231	18.000	18.000	VNFI	N=UP	3	8.50067E-02	-1.6724
233	12.000	15.000	VNFI	N=UP	2	4.40063E-02	.24657
235	8.0000	15.000	VNFI	N=UP	1	2.79999E-02	9.96626E-03
237	14.000	14.000	VNFI	N=UP	3	9.10034E-02	.24906
239	13.000	17.000	VNFI	N=UP	1	3.19977E-02	.14197
243	19.000	15.000	VNFI	N=UP	5	2.90070E-02	6.35123E-02
245	14.000	14.000	VNFI	N=UP	4	2.00043E-02	.13076
247	14.000	14.000	VNFI	N=UP	6	5.00031E-02	9.34871E-03
249	17.000	17.000	VNFI	N=UP	4	2.40021E-02	.13885
252	15.000	19.000	VNFI	N=UP	6	2.30103E-02	-.28018E-01
255	17.000	17.000	VNFI	N=UP	2	3.59955E-02	2.05501E-02
258	17.000	16.000	VNFI	N=UP	3	4.40063E-02	4.48339E-02
260	9.0000	17.000	VNFI	N=UP	2	3.50037E-02	9.90071E-02
262	17.000	16.000	VNFI	N=UP	3	2.09961E-02	3.86110E-02
265	13.000	17.000	VNFI	N=UP	1	1.89972E-02	8.96679E-02
268	15.000	16.000	VNFI	N=UP	1	1.49994E-02	2.49109E-02
270	14.000	13.000	VNFI	N=UP	5	1.40076E-02	.18181
273	17.000	15.000	VNFI	N=UP	5	2.40021E-02	.55851
276	15.000	16.000	VNFI	N=UP	5	6.19965E-02	.15006

278	17.000	7.0000	VNFI	N=UP	6	5.79987E-02	2.11771E-02
281	17.000	17.000	VNFI	N=UP	6	4.29993E-02	.10274
283	17.000	17.000	VNFI	N=UP	2	3.90015E-02	5.85340E-02
286	15.000	17.000	VNFI	N=UP	2	.25400	8.03286E-02
288	15.000	17.000	VNFI	N=UP	6	3.19977E-02	9.96626E-03
291	15.000	14.000	VNFI	N=UP	4	1.80054E-02	6.72461E-02
293	15.000	15.000	VNFI	N=UP	2	2.90070E-02	.12017
295	17.000	17.000	VNFI	N=UP	6	3.80096E-02	.11955
300	19.000	17.000	VNFI	N=UP	3	4.40063E-02	.11145
304	17.000	17.000	VNFI	N=UP	1	2.70081E-02	5.85340E-02
308	20.000	16.000	VNFI	N=UP	5	2.50092E-02	6.53840E-02
311	18.000	17.000	VNFI	N=UP	5	4.60052E-02	2.05501E-02
313	16.000	17.000	VNFI	N=UP	4	3.10059E-02	6.78732E-02
316	14.000	15.000	VNFI	N=UP	4	5.40009E-02	.14321

PARTITION FIX.UPDATE

#	R	ANG
2	3.30985E-02	4.3130
3	.13939	277.42
5	6.84581E-02	82.443
7	.20626	275.01
9	5.46749E-02	307.13
10	2.43783E-02	70.854
12	.11987	277.19
14	2.27594E-02	45.308
19	.11368	274.54
20	.19634	275.26
22	2.39069E-02	336.98
23	8.33842E-02	223.98
24	3.18143E-02	86.398
26	.16378	271.05
29	.12530	272.74
30	4.08024E-02	53.967
32	.26587	270.00
34	4.83086E-02	248.14
37	8.14714E-02	292.37
41	4.32348E-02	313.94
43	8.01558E-02	291.22

LONGITUDE ERROR HISTOGRAM PARTITION V.. FIX

46	6.85278E-02	311.04
47	5.72962E-02	243.01
48	4.76056E-02	289.65
49	.11109	277.24
51	7.19315E-02	303.79
53	6.24575E-02	279.22
58	8.30595E-02	290.44
63	9.07331E-02	275.69
65	5.19551E-02	297.51
67	.10212	295.52
69	.15520	279.27
70	2.91067E-02	333.29
73	.16158	280.70
75	.13290	278.66
77	4.42849E-02	346.16
79	3.25653E-02	17.803
82	.10494	323.18
83	.11540	289.23
85	5.54401E-02	294.52
86	6.40086E-02	304.22
88	.11076	281.99
91	6.34151E-02	280.92
94	4.82091E-02	264.06
96	8.53900E-02	280.12
100	8.67450E-02	295.25
103	6.42883E-02	255.60
104	5.21883E-02	294.94
106	9.68333E-02	291.19
108	4.39405E-02	311.31
109	7.60272E-02	272.27
110	7.88471E-02	294.75
112	7.46198E-02	280.03
113	6.19246E-02	298.98
117	.20609	280.91
119	3.33124E-02	302.72
122	2.30185E-02	.00000
124	.12052	281.01
126	.18401	286.74
127	4.47753E-02	328.09
129	.14874	278.90

131	7.00321E-02	1.5237
132	3.51065E-02	322.90
138	4.58181E-02	285.19
140	8.38944E-02	289.50
142	7.64533E-02	319.34
143	4.79604E-02	294.65
145	8.71843E-02	270.00
146	5.98151E-02	299.01
148	9.59192E-02	281.42
150	2.17462E-02	297.41
151	4.94714E-02	291.34
156	9.12830E-02	288.53
158	.11190	275.13
159	6.07825E-02	280.43
163	.15652	282.92
165	5.23302E-02	313.46
166	.11445	286.76
170	.11504	287.71
173	.19572	292.22
174	5.69101E-02	314.67
176	.15133	275.31
178	6.30369E-02	288.50
179	3.71636E-02	316.61
181	.11137	281.92
184	2.55017E-02	348.72
186	.10091	271.71
189	4.00747E-02	293.54
190	9.39792E-02	279.18
194	8.81594E-02	275.20
195	6.53692E-02	292.49
197	9.30949E-02	280.52
203	6.03684E-02	310.24
205	9.36465E-02	288.04
207	4.71150E-02	314.47
209	4.14230E-02	325.16
211	3.08026E-02	321.19
215	7.55945E-02	301.95
217	.11097	282.49
219	.11239	288.68
221	5.70564E-02	317.41

222	5.74761E-02	316.96
226	.12726	283.18
232	4.29741E-02	271.34
234	9.67039E-02	266.44
236	4.88488E-02	324.99
238	2.06498E-02	336.92
240	.11671	273.93
241	3.88620E-02	347.98
244	9.54314E-02	286.44
246	8.50311E-02	286.40
253	5.65705E-02	300.85
254	9.84243E-02	285.93
256	6.33585E-02	289.35
257	.11096	289.48
259	7.31384E-02	297.70
261	5.41749E-02	296.30
264	.13612	278.87
267	4.08127E-02	297.74
269	.11268	288.10
275	7.17179E-02	310.94
277	.13443	289.11
279	.29698	297.25
280	2.74248E-02	341.46
282	.13645	279.71
287	9.39364E-02	276.12
290	2.76543E-02	295.74
292	.10911	286.51
294	4.07515E-02	311.51
298	.10590	271.63
301	6.78509E-02	306.13
302	8.08620E-02	324.72
303	4.23007E-02	302.95
305	.16401	307.13
306	8.87840E-02	275.17
307	8.77506E-02	285.20
309	.11330	291.76
310	7.81084E-02	310.77
312	.11567	282.99
315	4.91330E-02	320.68

PARTITION FIX.NOUPDATE

#	R	ANG
1	9.82766E-02	343.05
16	8.44249E-02	225.67
28	6.61434E-02	261.31
35	.28149	275.51
39	.10163	298.82
44	.16306	80.112
55	3.58826E-02	329.78
57	.11849	350.92
60	8.11263E-02	309.87
62	.21619	301.82
72	.12597	298.97
81	.11116	310.37
90	.15043	213.12
93	.34042	58.866
98	6.02093E-02	291.43
102	7.11049E-02	10.081
115	.18291	277.86
121	.13213	261.73
134	.32009	276.28
136	9.07093E-02	230.25
137	.14071	14.870
153	5.35445E-02	254.85
154	.19510	267.35
161	.24775	79.299
168	.15451	292.05
172	.10324	244.78
183	8.80723E-02	312.06
187	8.97406E-02	296.48
192	.12457	286.32
199	.24932	274.83
201	.96836	273.08
212	5.27575E-02	294.65
214	.14038	289.13
224	2.0011	92.434
228	.89686	86.676
230	1.2455	86.686
242	.25259	276.59

248	3.92715E-02	75.233
250	6.60318E-02	268.26
251	2.18229E-02	336.44
263	.37126	347.90
266	.24658	235.41
271	6.00414E-02	218.49
272	.68327	271.51
274	1.2449	335.41
285	4.7179	280.30
289	6.78962E-02	290.70
296	.10577	232.08
297	4.57013E-02	64.042
299	5.97464E-02	56.467
314	8.46369E-02	332.39

PARTITION VNFIX

#	R	ANG
4	.10650	282.48
6	4.31542E-02	69.661
8	.12909	280.27
11	5.60025E-02	294.26
13	.10905	278.97
15	.10744	290.14
21	9.33615E-02	286.17
25	2.90781E-02	301.05
27	.11469	276.51
31	3.33354E-02	343.71
33	.17180	274.68
36	.47196	90.000
38	6.55499E-02	301.24
40	.12488	288.68
42	.13587	288.45
45	.22744	272.27
50	5.86795E-02	65.856
52	9.18316E-02	291.73
54	.16339	281.65
56	.18478	284.73
59	.14729	273.90

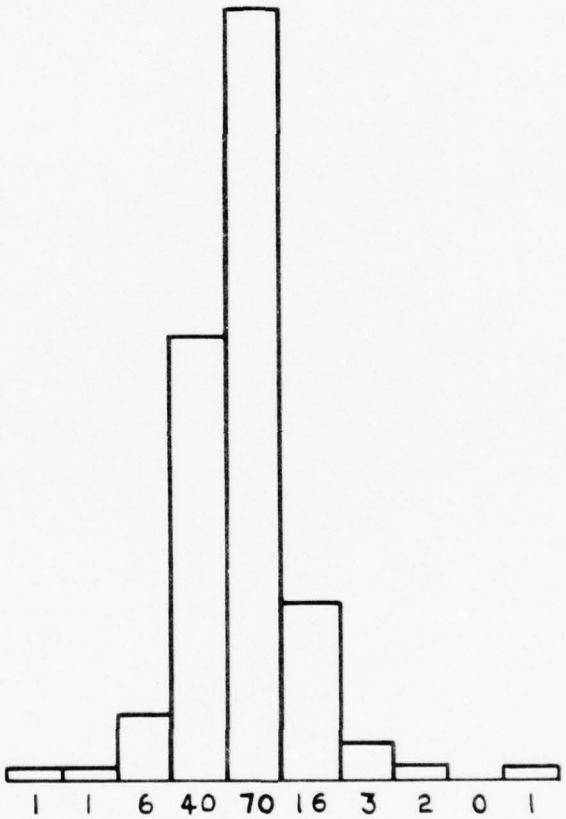
61	.31419	77.687
64	.10119	274.53
66	.14151	286.42
68	.14774	286.92
71	.15882	289.11
74	.16648	280.38
76	8.14873E-02	299.40
78	.18092	296.95
80	.10511	290.61
84	6.42383E-02	315.74
87	.11810	293.45
89	.10286	282.93
92	2.81950E-02	343.32
95	.14952	268.09
97	4.48829E-02	310.26
99	3.89369E-02	294.27
101	4.10863E-02	346.85
105	.12522	285.28
107	6.18088E-02	309.12
111	6.40752E-02	305.27
114	9.53102E-02	290.90
116	5.08378E-02	27.732
118	4.44442E-02	8.0489
120	.17750	286.02
123	.17219	291.10
125	5.97966E-02	17.570
128	8.46388E-02	299.76
130	4.70302E-02	330.67
133	.10594	298.16
135	.12397	81.649
139	9.12830E-02	288.53
141	3.87420E-02	338.30
144	.13409	286.02
147	7.55363E-02	292.58
149	8.21736E-02	284.09
152	6.98976E-02	289.22
155	.64587	256.11
157	6.55647E-02	303.30
160	4.61587E-02	279.97
162	.44183	272.33

164	7.45414E-02	302.46
167	6.00492E-02	2.3757
169	2.8749	68.535
171	6.82729E-02	14.795
175	.15777	293.14
177	7.02406E-02	295.28
180	.15077	288.96
182	4.54454E-02	326.76
185	9.49331E-02	294.26
188	.32253	286.76
191	4.03993E-02	352.02
193	3.6791	250.77
196	.10791	286.70
198	6.37656E-02	296.05
200	.87592	273.60
202	1.2578	90.410
204	3.48568E-02	341.24
206	8.09635E-02	290.23
208	.16851	293.06
210	.14080	290.36
213	.26067	51.576
216	8.04054E-02	299.84
218	6.14568E-02	305.85
220	4.20259E-02	1.6971
223	.17068	290.94
225	.27947	280.72
227	6.26069E-02	351.99
231	1.6746	87.090
233	.25047	280.12
235	2.97207E-02	340.41
237	.26517	290.07
239	.14553	282.70
243	6.98227E-02	294.55
245	.13228	278.70
247	5.08695E-02	349.41
249	.14091	279.81
252	3.62555E-02	50.604
255	4.14485E-02	330.28
258	6.28223E-02	314.47
260	.10501	289.47

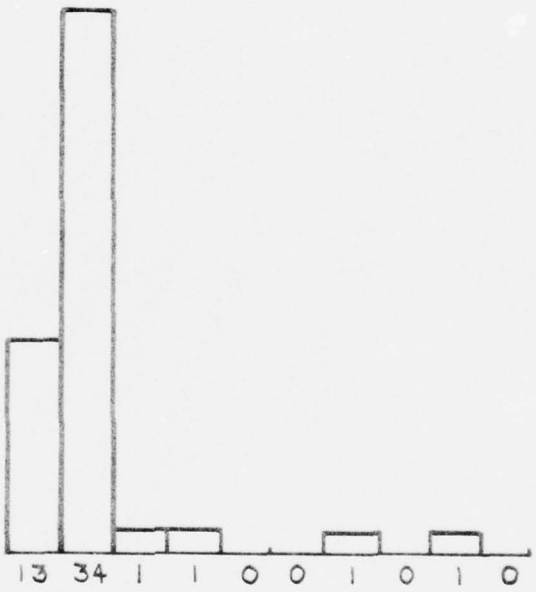
262	4.39504E-02	298.54
265	9.16581E-02	281.96
268	2.90781E-02	301.05
270	.18235	274.41
273	.55902	272.46
276	.16237	292.45
278	6.17439E-02	339.94
281	.11138	292.71
283	7.03373E-02	303.68
286	.26640	342.45
288	3.35138E-02	342.70
291	6.96149E-02	284.99
293	.12363	283.57
295	.12544	287.64
300	.11983	291.55
304	6.44644E-02	294.77
308	7.00037E-02	290.93
311	5.03864E-02	335.93
313	7.46199E-02	294.55
316	.15306	290.66

APPENDIX F

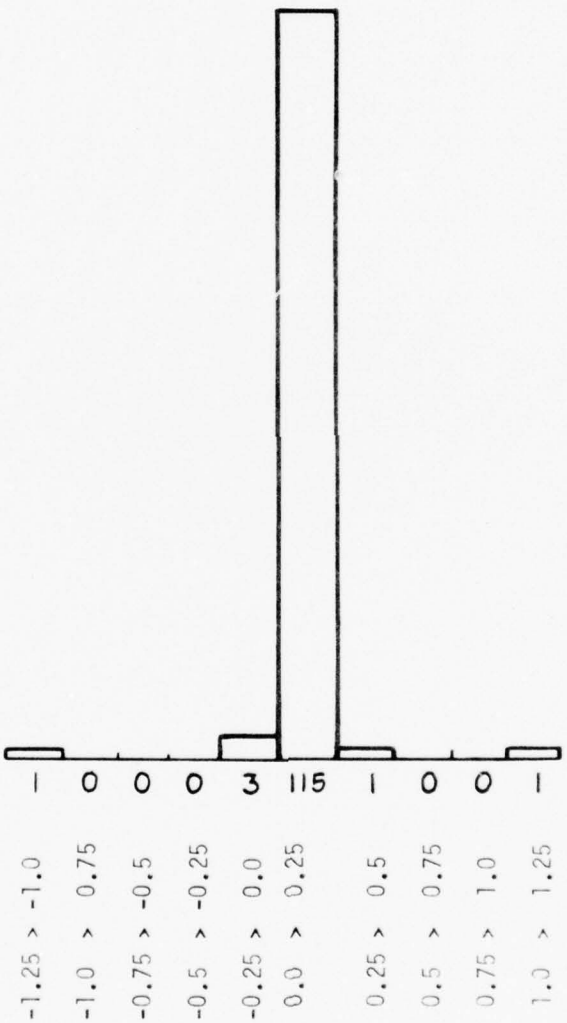
LATITUDE ERROR HISTOGRAM, PARTITION FIX: UPDATE



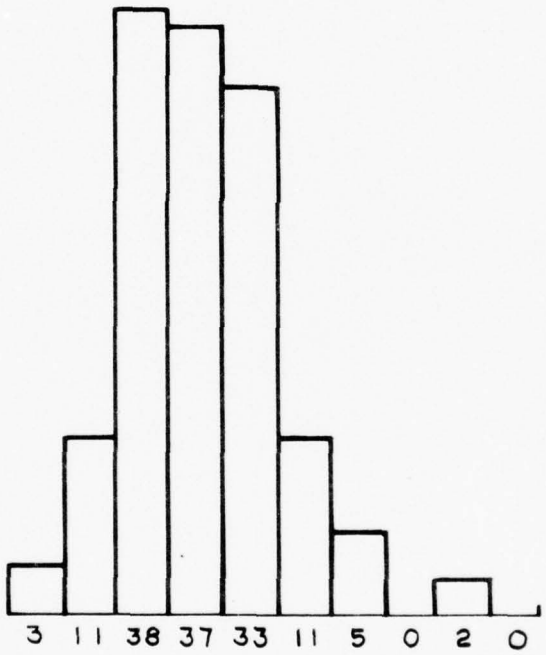
LATITUDE ERROR HISTOGRAM, PARTITION FIX: N-UPDATE



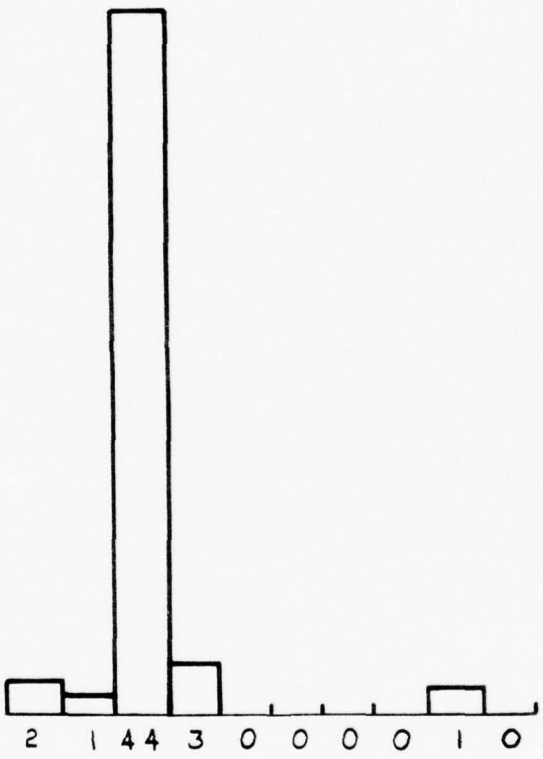
LATITUDE ERROR HISTOGRAM, PARTITION: V_N FIX



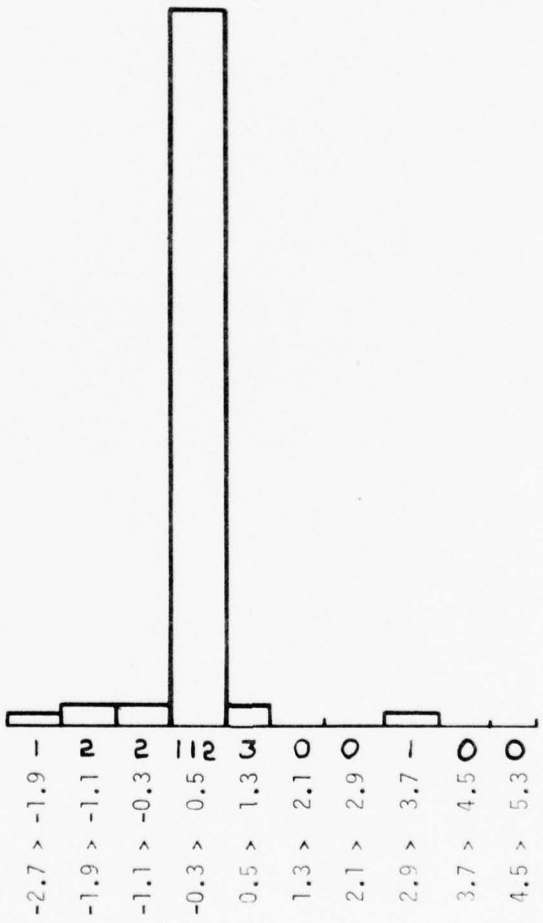
LONGTITUDE ERROR HISTOGRAM, PARTITION FIX: UPDATE



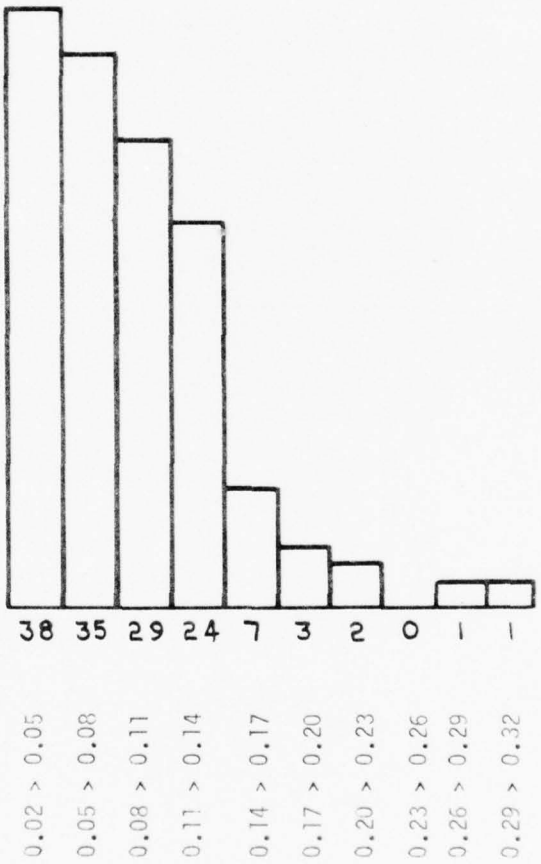
LONGTITUDE ERROR HISTOGRAM, PARTITION FIX: N-UPDATE



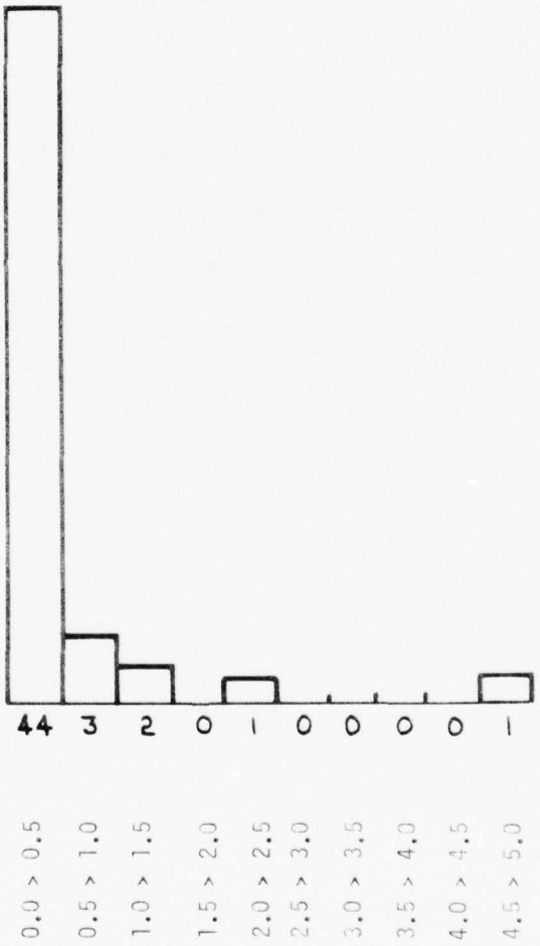
LONGTITUDE ERROR HISTOGRAM, PARTITION V_N FIX



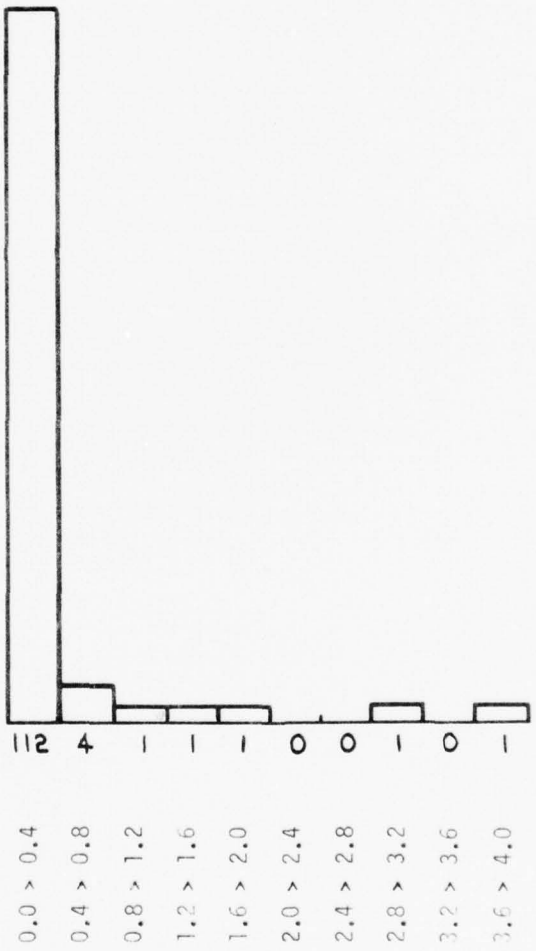
RADIAL ERROR HISTOGRAM, PARTITION FIX: UPDATE



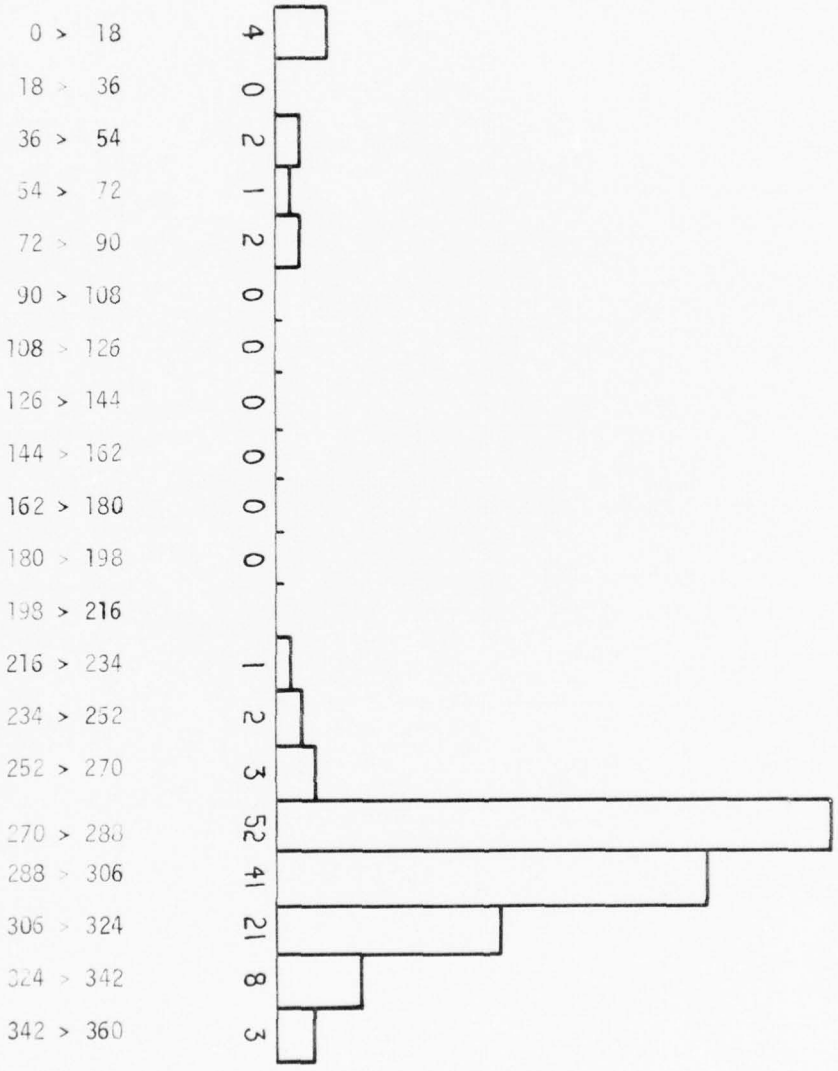
RADIAL ERROR HISTOGRAM, PARTITION FIX:N-UPDATE



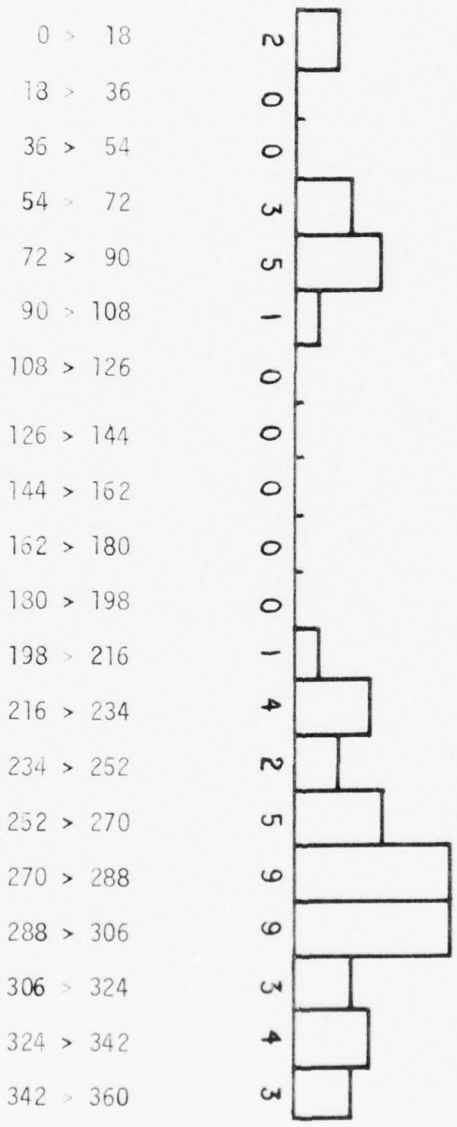
RADIAL ERROR HISTOGRAM, PARTITION V_N FIX



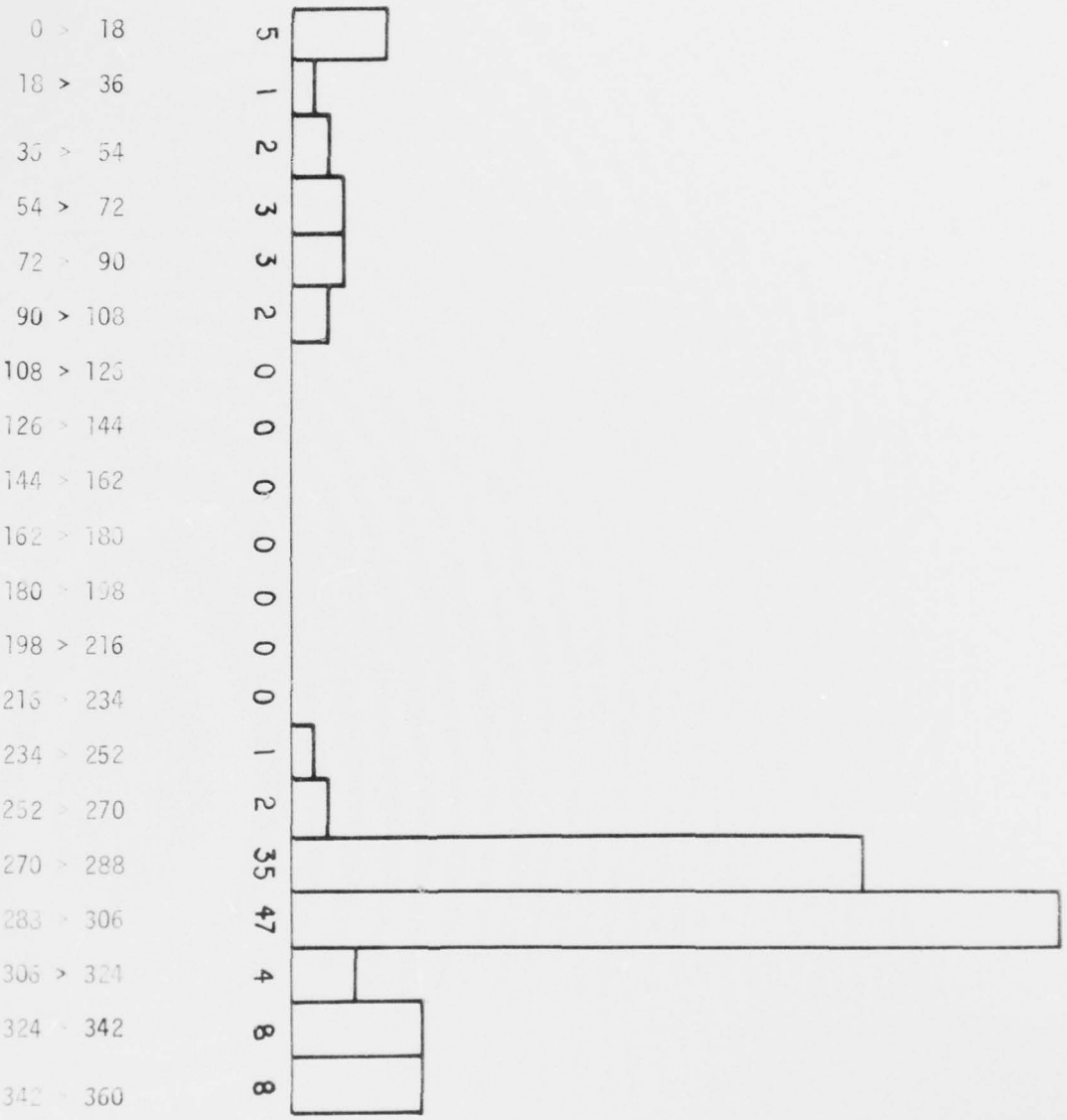
BEARING FROM TRUE NORTH HISTOGRAM, PARTITION FIX: DATE



BEARING FROM TRUE NORTH HISTOGRAM, FIX: N - UPDATE PARTITION

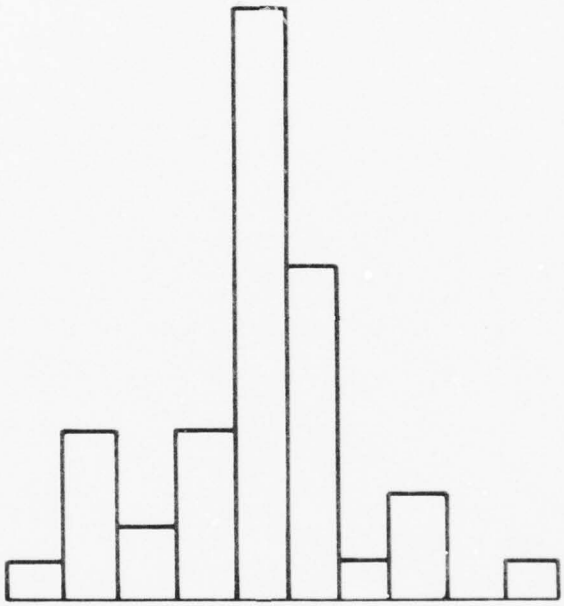


BEARING FROM TRUE NORTH HISTOGRAM, PARTITION V_N FIX

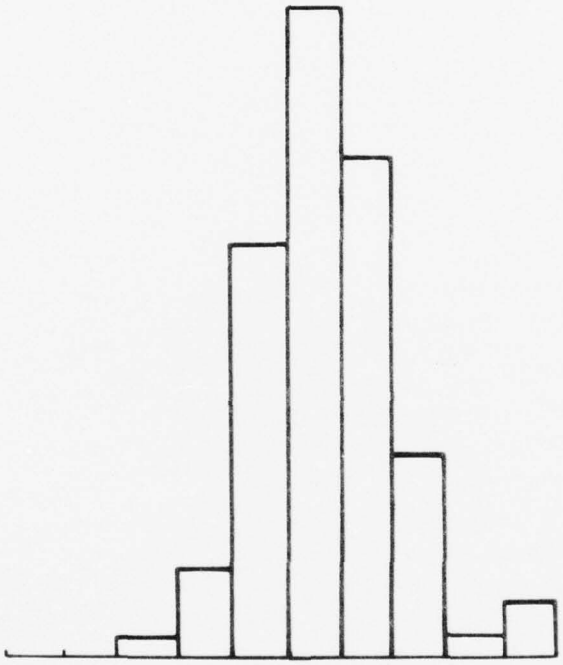


APPENDIX G

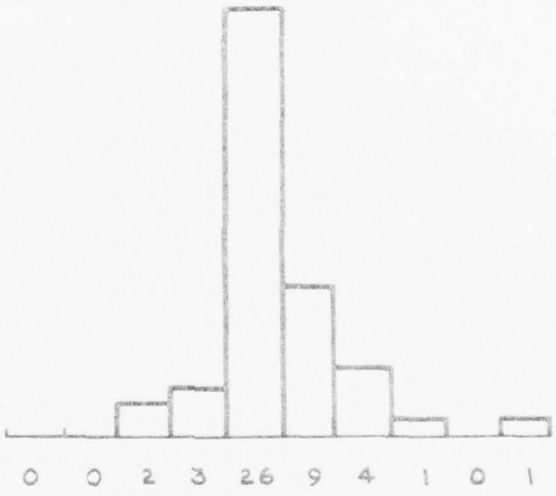
DETAIL FROM LATITUDE ERROR HISTOGRAM, PARTITION FIX:N – UPDATE



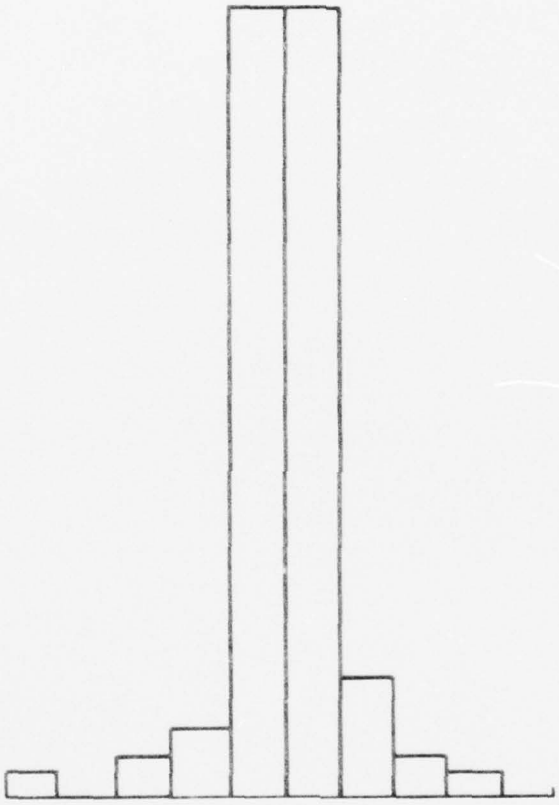
DETAIL FROM LATITUDE ERROR HISTOGRAM, PARTITION: V_N FIX



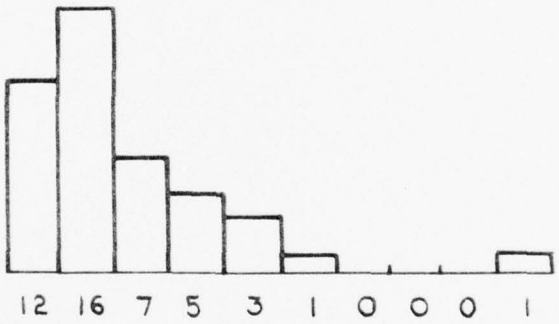
DETAIL FROM LONGTITUDE ERROR HISTOGRAM, PARTITION FIX: N-UPDATE



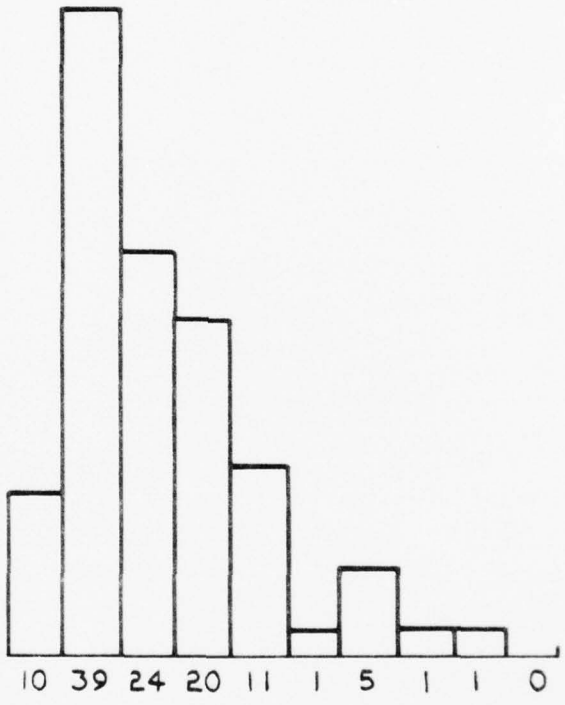
DETAIL FROM LONGTITUDE ERROR HISTOGRAM, PARTITION: V_N FIX



DETAIL FROM RADIAL ERROR HISTOGRAM, PARTITION FIX:N - UPDATE

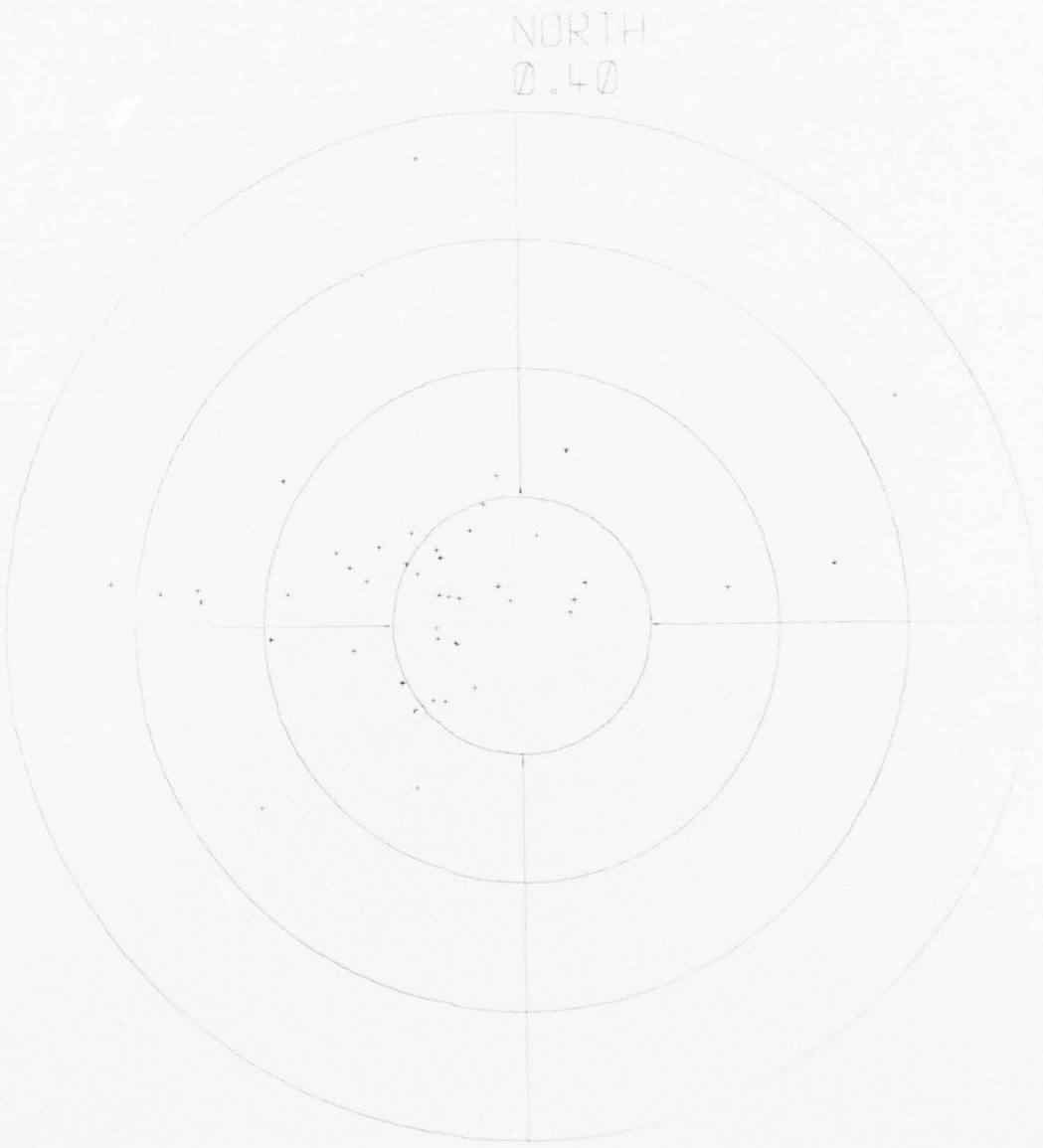


DETAIL FROM RADIAL ERROR HISTOGRAM, PARTITION : V_N FIX

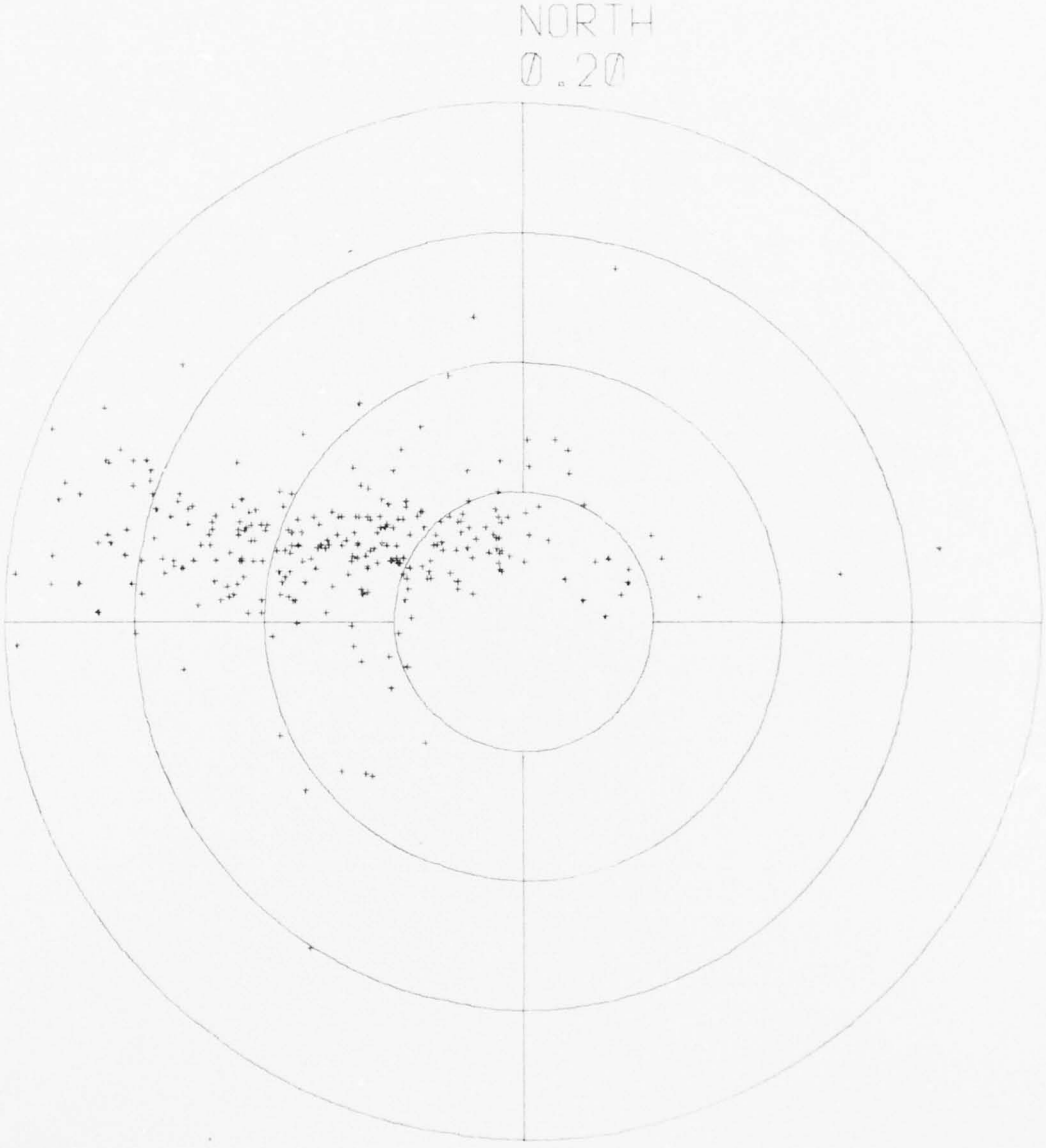


APPENDIX H

FIX UPDATE



FIX.N-UPDATE



VNFIX

APPENDIX I: LISTING OF PROGRAM /SAT3

```
* # 4141TAJ  /SAT3-SY:SATNAV MONDAY JUN 30, 1975 4:19:02 PM
ø     CARD
C     SAT3.  THIS PROGRAM READS LAT ERRORS AND LONG ERRORS
C     FROM A USER SPECIFIED FILE AND PRODUCES A DATA FILE
C     WHICH CAN BE USED BY THE CIL PLOTTER
C
        INTEGER TITLE(3)
          DIMENSION ELAT(350), ELON(350), IFILE(5), OFILE(5)
C     DEFINE INPUT AND OUTPUT FILES
          PRINT ('PROGRAM SAT3'/, 3X, 'SCATTER PLOT ROUTINE'/)
          OPEN(2, INPUT, PROMPT 'INPUT DATA FILE ', IFILE)
          OPEN(1, BINARY OUTPUT, PROMPT 'PLOT FILE ', OFILE)
          DECODE(16,(5A4), OFILE) OFILE
          DECODE(16,(5A4), IFILE) IFILE
          CALL PLOTS (1)
C     READ IN A TITLE
        DISPLAY 'PLOT TITLE '
          ACCEPT 110, TITLE
C     READ INFIXES AND COUNT THE NUMBER READ
          ICNT=0
10        READ (2, 100, END=20) ELAT(ICNT+1), ELON(ICNT+1)
          ICNT=ICNT+1
C     LONGITUDES ARE WEST, GET THE CORRECT ORIENTATION
          ELON(ICNT)=-ELON(ICNT)
          GOTO 10
20      DISPLAY 'OUTER LIMIT(NM) '
          ACCEPT 100, OL
C     TEST FOR COINCIDENCE OF POINTS
```

```
      DO 40 I=1, ICNT-1
      DO 30 J=I+1, ICNT
      IF(ELAT(I).NE.ELAT(J).OR.ELON(I).NE.ELON(J)) GOTO 30
      PRINT('POINTS THE SAME  LAT ',F.3X,'LON ',F,3X,
     &   'I=', I,3X,' J=',I), ELAT(I),ELON(I),I,J
30    CONTINUE
40    CONTINUE
C     DRAW COMPASS LINES AND CIRCLES
      CALL PLOT(10., 10.,-3)
      CALL POL(0.,0.,8.,4,4,0)
C     ANOTATE THE GRID
      CALL SYMBOL(0.,9.,0.5,'NORTH',0.,5)
      CALL NUMBER(0.,8.25,0.5,0L,0.,2)
C     PLOT THE POINTS
      DO 60 I=1,ICNT
C     TEST IF POINT IS WITHIN THE LIMITS
      IF(SQRT(ELAT(I)**2+ELON(I)**2).LE.0L) GOTO 50
      PRINT('OUT OF RANGE LAT  ',F,3X,'LON ',F,3X,
     &   'I=',I), ELAT(I), ELON(I), I
      GOTO 60
50    X=(ELON(I)/0L)*8
      Y=(ELAT(I)/0L)*8
      CALL GRAF(X,Y,0.1.2)
60    CONTINUE
C     PRINT THE TITLE
      CALL SYMBOL(-8.,-10.,0.5,TITLE,0.,12)
C     FINISH PLOTTING
      CALL PLOT (0.,0.,999)
      CLOSE
```

```
      PRINT(/'END OF PROGRAM')
      STOP
C
C     FORMATS
C
100   FORMAT(2G)
110   FORMAT(3A4)
C
      END
```

	DAY	MINS	ITER	ELEY	FREQ	NOBC	NOAC	ELAT	ELON	R	ANG
DAY	1.0000	1									
MINS	-0.2520	1.0000									
ITER	-0.0251	0.0294	1.0000								
ELEY	-0.0048	-0.0676	-0.1420	1.0000							
FREQ	-0.3441	-0.0769	-0.0309	-0.1147	1.0000						
NOBC	-0.0270	-0.0944	0.0318	0.6875	-0.1283	1.0000					
NOAC	-0.0036	-0.0711	-0.0504	0.7918	-0.0029	0.6901	1.0000				
ELAT	0.2883	-0.1310	-0.0000	-0.0185	0.3207	-0.0267	0.0250	1.0000			
ELON	0.0503	-0.0675	-0.0941	-0.0901	0.1281	-0.0520	-0.0632	0.1430	1.0000		
R	-0.0078	-0.0799	-0.0612	0.1062	0.0933	-0.0582	-0.0547	0.2572	0.9518	1.0000	
ANG	0.3666	-0.0993	-0.2500	-0.0228	0.2840	-0.0119	-0.0093	0.1691	0.2741	0.1098	1.0000

Where:- DAY is Julian Day of fix.

MIN is number of minutes after midnight of fix.

ITER is the number of iterations in the fix calculation.

ELEY is the maximum elevation of the satellite.

FREQ is the offset frequency of the receiver.

NOBC is the number of Doppler counts before the centre of pass.

NOAC is the number of Doppler counts after the centre of pass.

ELAT is the latitude error in nautical miles of the fix.

ELON is the longitude error in nautical miles of the fix.

R is the radial error in nautical miles of the fix.

ANG is the bearing of the fix from true North.

AD-A043 757 ADMIRALTY SURFACE WEAPONS ESTABLISHMENT PORTSMOUTH (E--ETC F/G 17/7
THE STATIC PERFORMANCE OF THE MX902 SATELLITE NAVIGATION EQUIPM--ETC(U)
APR 76 P A KENNEDY, T A JONES

UNCLASSIFIED ASWE-TR-76005 DRIC-BR-48738 NL

2 OF 2
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END
DATE FILMED
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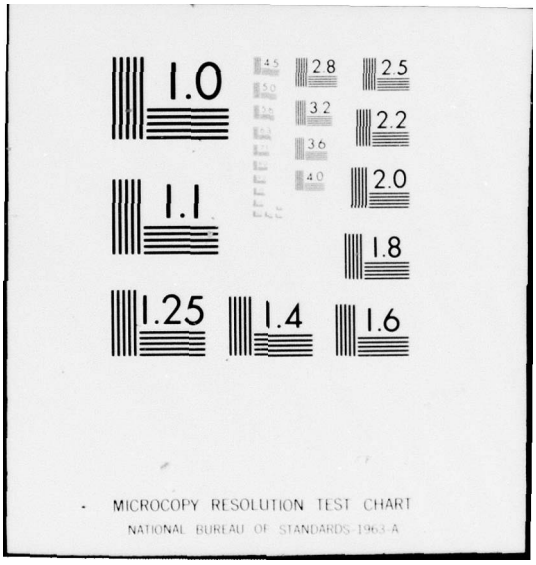
DDC


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

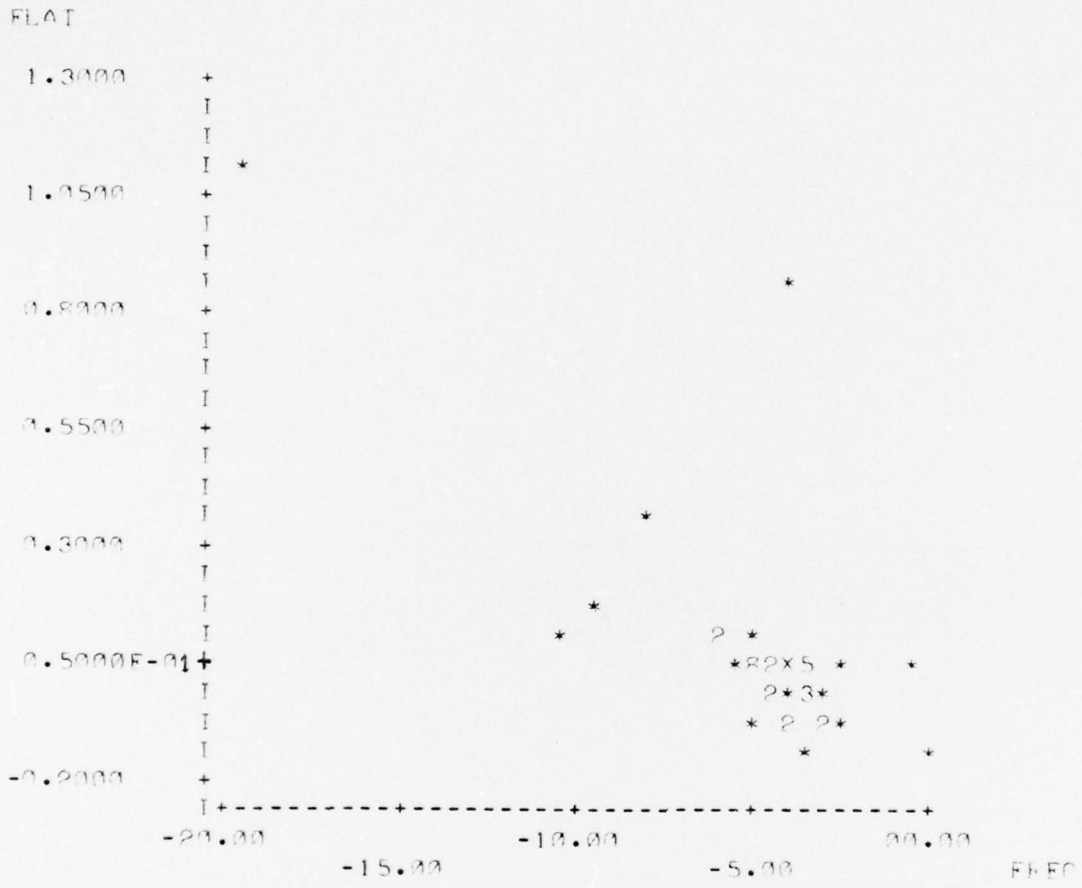
Correlation matrix for Partition Fix: N-UPDATE

	DAY	MINS	ITER	ELEY	FREQ	NOBC	NOAC	ELAT	ELON	R	ANG
DAY	1.0000										
MINS	-0.2287	1.0000									
ITER	-0.2917	0.0996	1.0000								
ELEY	0.1419	0.0509	0.1359	1.0000							
FREQ	0.0744	0.0467	-0.1146	0.2332	1.0000						
NOBC	0.1882	-0.0106	0.1497	0.7831	0.1540	1.0000					
NOAC	0.1610	0.0771	0.0889	0.9260	0.2312	0.7021	1.0000				
ELAT	0.1889	-0.1622	-0.0222	-0.1176	-0.7140	0.0306	-0.0144	1.0000			
ELON	0.0989	0.0161	0.0251	-0.1120	-0.0117	0.1063	0.0288	0.5353	1.0000		
R	0.2662	-0.0875	-0.0275	0.1701	-0.1009	0.2863	0.2656	0.6057	0.5740	1.0000	
ANG	-0.0814	-0.2295	0.1037	-0.2458	-0.1017	-0.2436	-0.1503	0.1714	0.3257	-0.0552	1.0000

Correlation matrix for Partition: V_N FIX

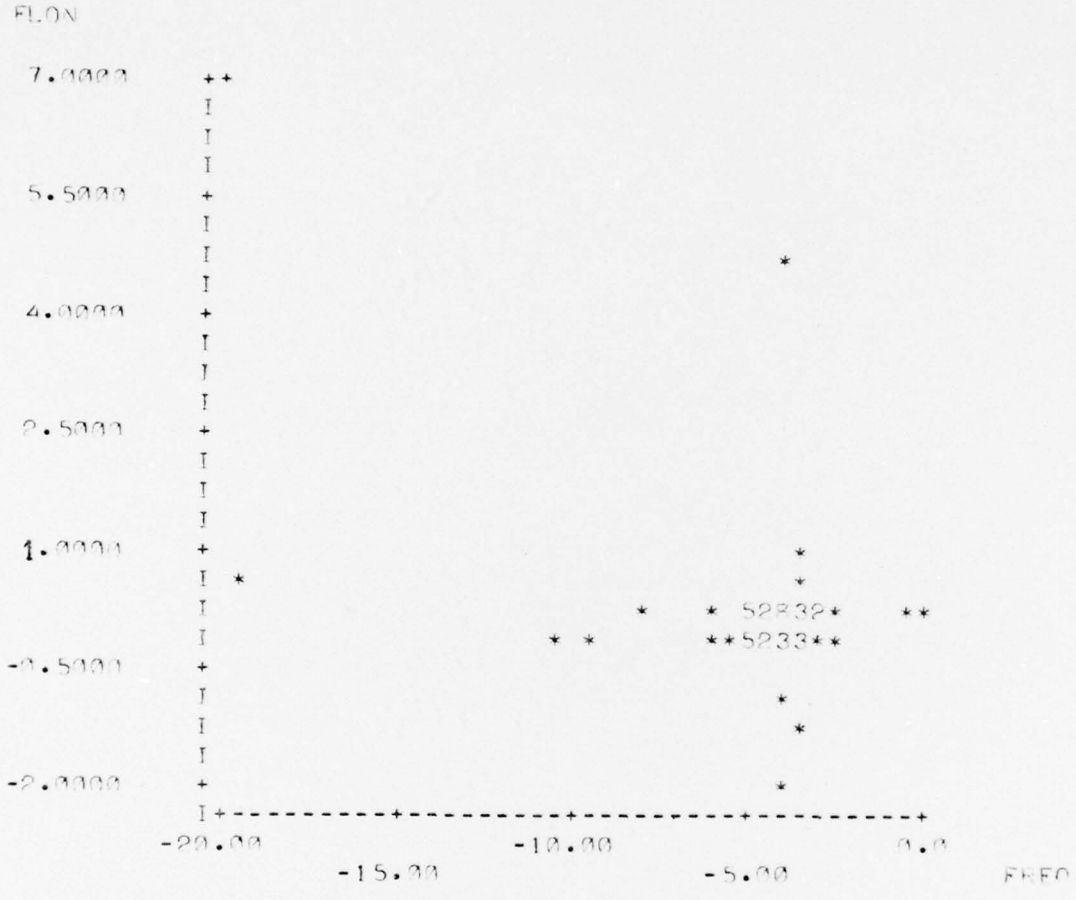
	DAY	MINS	ITER	ELEY	FREQ	NOBC	NOAC	ELAT	ELON	R	ANG
DAY	1.0000										
MINS	-0.2177	1.0000									
ITER	-0.1431	-0.0547	1.0000								
ELEY	0.0050	0.0202	-0.3428	1.0000							
FREQ	0.0792	0.0496	-0.0480	-0.0022	1.0000						
NOBC	0.0073	-0.1432	0.3868	0.2212	-0.0556	1.0000					
NOAC	-0.0405	-0.0156	-0.0446	0.5627	-0.0380	0.2501	1.0000				
ELAT	0.0353	-0.1005	0.0332	-0.0390	-0.9359	0.0474	0.0238	1.0000			
ELON	0.0053	0.0347	0.0378	-0.0784	0.8132	-0.1539	-0.0682	-0.8449	1.0000		
R	0.0779	0.0869	-0.4600	0.1377	0.2601	-0.4001	-0.1080	-0.1977	0.0636	1.0000	
ANG	0.0903	-0.0103	0.3288	-0.2983	0.0843	0.0152	-0.1111	-0.1239	0.3038	-0.2400	1.0000

APPENDIX K: GRAPHS OF LATITUDE ERROR (FLAT) AND LONGITUDE ERROR (FLON) AGAINST OFFSET FREQUENCY



PARTITION: FIX.NOUPDATE

NOTE: * IS ONE POINT
1>9 INDICATES THE NUMBER OF MEASUREMENTS AT THAT POINT
X INDICATES TEN OR MORE MEASUREMENTS AT THAT POINT



PARTITION: FIX.NOUPDATE

Appendix L: Output from stepwise regression program to test position errors against day, minutes, iterations, elevation, offset frequency, number of Doppler counts before centre and number of Doppler counts after centre of pass.

```
REG>  STE ELAT ON: V1-V7 BYP
```

LATITUDE ERROR

```
PARTITION FIX.UPDATE


EQUATION
    ELAT = - . 07073  +  .00178*DAY  +  .00490*FREQ

R-SQUARED = .13874


PROCEDURE SUMMARY

            VARIABLE              R-SQUARED              F-RATIO
STEP    ENTERED    REMOVED   VALUE  % CHANGE    CRITERION     ACTUAL

  1     FREQ                 .1028                  3.91        15.82
  2     DAY                  .1387   34.90          3.91         5.71

PROCEDURE ENDED WHEN
  MAXIMUM F TO ENTER  =  .63 FOR MINS
  FAILED TO MEET F ACCEPT  =  3.91
```

LATITUDE ERROR

```
PARTITION FIX.NOUPDATE


EQUATION
    ELAT  =  - 1.6329  +  .02179*DAY  -  .05514*FREQ

R-SQUARED  =  .56864


PROCEDURE SUMMARY

            VARIABLE              R-SQUARED              F-RATIO
STEP    ENTERED    REMOVED   VALUE  % CHANGE    CRITERION     ACTUAL

  1     FREQ                 .5098                  4.04        50.95
  2     DAY                  .5686   11.55          4.04         6.55

PROCEDURE ENDED WHEN
  MAXIMUM F TO ENTER  =  1.63 FOR NOAC
  FAILED TO MEET F ACCEPT  =  4.05
```

LATITUDE ERROR

PARTITION VNFIX

EQUATION
ELAT = - .56871 + .00727*DAY - .02907*FREQ

R-SQUARED = .88802

PROCEDURE SUMMARY

STEP	VARIABLE ENTERED	VARIABLE REMOVED	R-SQUARED VALUE	R-SQUARED % CHANGE	F-RATIO CRITERION	F-RATIO ACTUAL
1	FREQ		.8760		3.92	840.59
2	DAT		.8880	1.37	3.92	12.68

PROCEDURE ENDED WHEN
MAXIMUM F TO ENTER = 1.84 FOR ELEY
FAILED TO MEET F ACCEPT = 3.92

REF> STE ELON ON: V1-V7 BYP

LONGITUDE ERROR

PARTITION FIX.UPDATE

PROCEDURE SUMMARY

NO INDEPENDENT VARIABLE QUALIFIED FOR ENTRY

PROCEDURE ENDED WHEN
MAXIMUM F TO ENTER = 2.30 FOR FREQ
FAILED TO MEET F ACCEPT = 3.91

LONGITUDE ERROR

PARTITION FIX.NOUPDATE

PROCEDURE SUMMARY

NO INDEPENDENT VARIABLE QUALIFIED FOR ENTRY

PROCEDURE ENDED WHEN
MAXIMUM F TO ENTER = .62 FOR ELEY
FAILED TO MEET F ACCEPT = 4.04

LONGITUDE ERROR

PARTITION VNFIX

EQUATION

ELON = .18602 + .16387*ITER + .07753*FREQ - .01791*NOBC

R-SQUARED = .68966

PROCEDURE SUMMARY

	VARIABLE		R-SQUARED		F-RATIO	
STEP	ENTERED	REMOVED	VALUE	% CHANGE	CRITERION	ACTUAL
1	FREQ		.6612		3.92	232.27
2	NOBC		.6731	1.79	3.92	4.27
3	ITER		.6897	2.46	3.92	6.25

PROCEDURE ENDED WHEN

MAXIMUM F TO ENTER = .55 FOR DAY

FAILED TO MEET F ACCEPT = 3.92

APPENDIX M: CORRELATION MATRIX, FOR EACH PARTITION, OF MEASURED POSITION ERRORS EITH EQUIPMENT CALCULATED ERRORS

PARTITION FIX.UPDATE

140 OBSERVATIONS

	LATE	LONE	ALAT	ALON	SLA	SLO	RMS
LATE	1.0000						
lone	.1430	1.0000					
ALAT	.8317	.1342	1.0000				
ALON	.1223	.9642	.1030	1.0000			
SLA	- .0102	.01433	.2021	- .0202	1.0000		
SLO	- .0347	.0284	-.0482	.0260	- .1021	1.0000	
RMS	.0351	- .0277	.0481	.0253	.1006	-1.0000	1.0000

PARTITION FIX.NOUPDATE

51 OBSERVATIONS

	LATE	LONE	ALAT	ALON	SLA	SLO	RMS
LATE	1.0000						
LONE	.5353	1.0000					
ALAT	.9513	.5175	1.0000				
ALON	.4947	.5654	.5306	1.0000			
SLA	.8566	.4543	.9513	.4572	1.0000		
SLO	.1838	- .1842	.2565	.6052	.2566	1.0000	
RMS	.5861	.8147	.6031	.8943	.5354	.2797	1.0000

PARTITION UNFIX

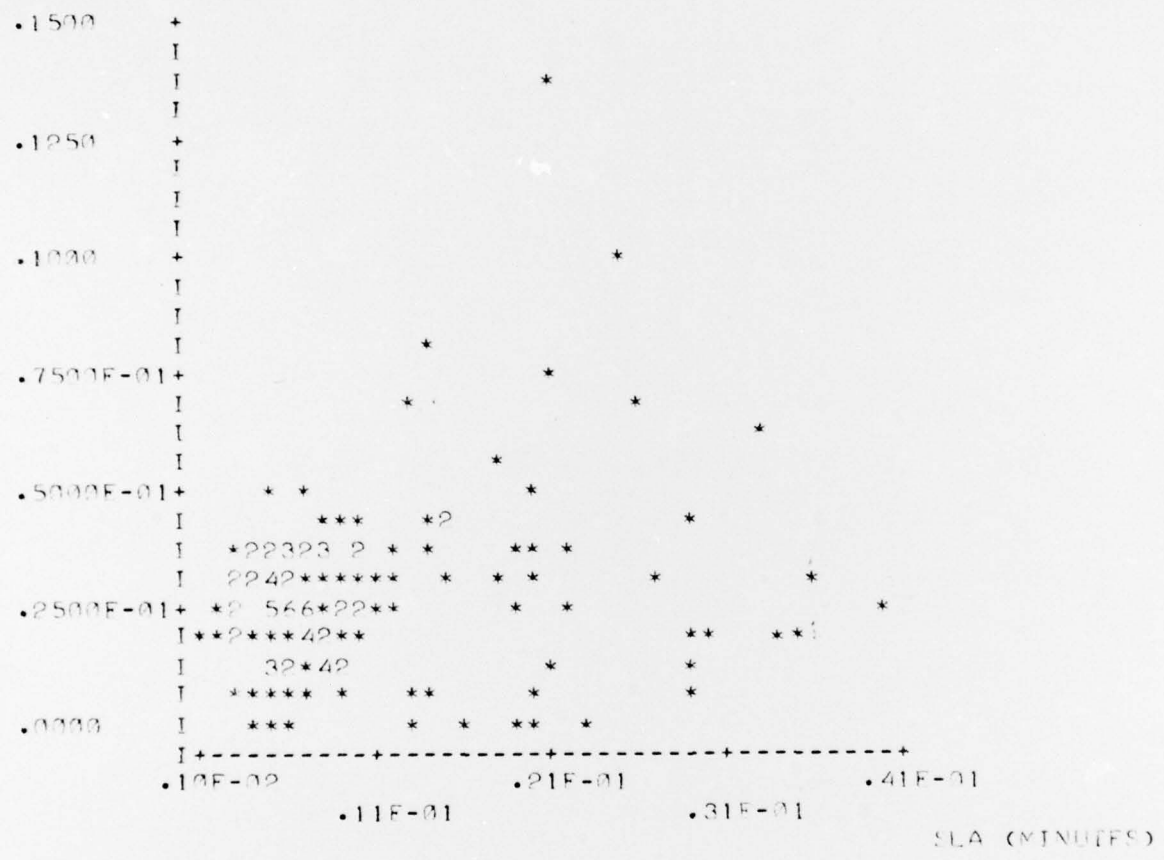
121 OBSERVATIONS

	LATE	LONE	ALAT	ALON	SLA	SLO	RMS
LATE	1.0000						
LONE	- .8449	1.0000					
ALAT	-.1375	.1536	1.0000				
ALON	- .2072	.0617	.8658	1.0000			
SLA	.2879	- .2590	.8588	.7587	1.0000		
SLO	.2179	- .4298	.6274	.7935	.7589	1.0000	
RMS	.2765	- .2460	.0904	.0872	.1152	.1955	1.0000

NOTE: LATE - LATITUDE ERROR IN DEGREES
LONE - LONGITUDE ERROR IN DEGREES
ALAT - ABSOLUTE VALUE OF LATITUDE ERROR
ALON - ABSOLUTE VALUE OF LONGITUDE ERROR
SLA - EQUIPMENT CALCULATED LATITUDE ERROR
SLO - EQUIPMENT CALCULATED LONGITUDE ERROR
RMS - EQUIPMENT CALCULATED RMS POSITION ERROR IN NM

APPENDIX N: GRAPHS OF MEASURED POSITION ERRORS AGAINST EQUIPMENT CALCULATED ONES.

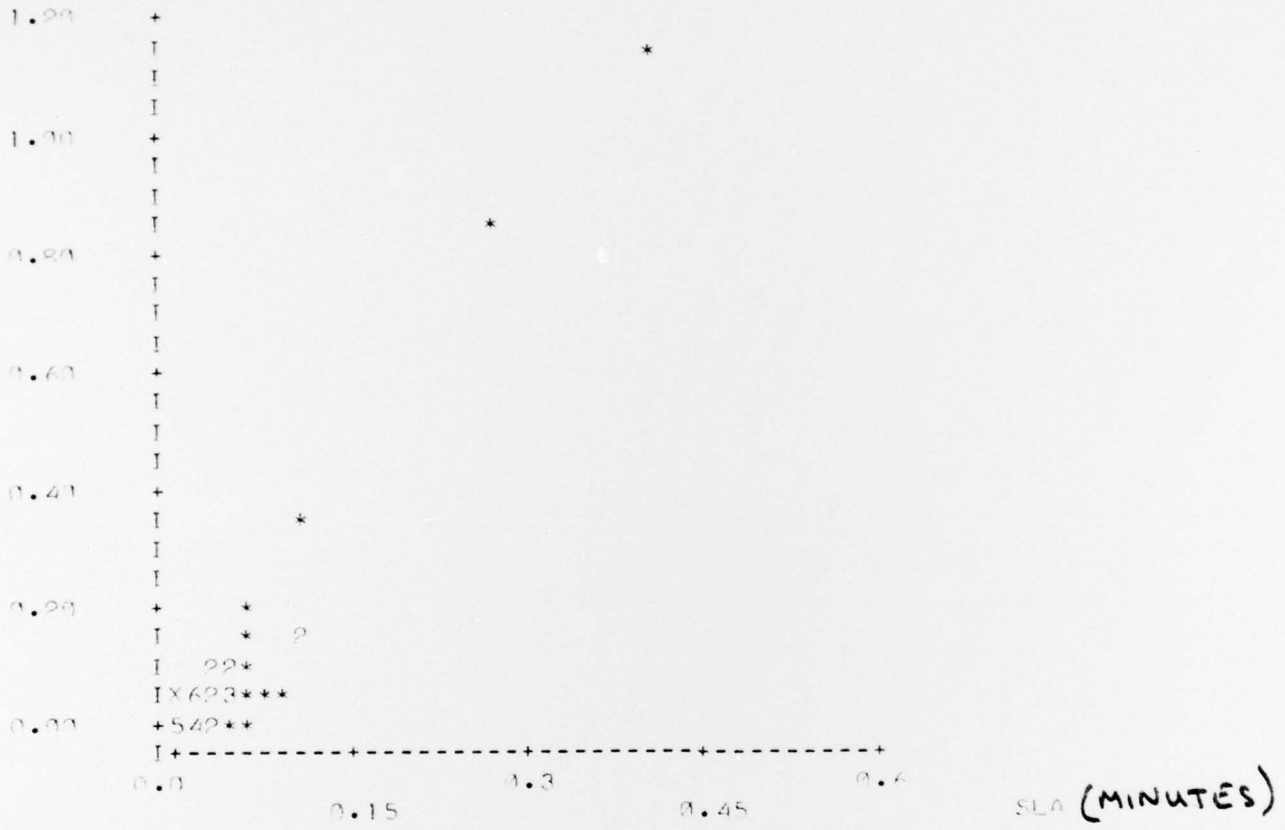
PARTITION FIX.UPDATE



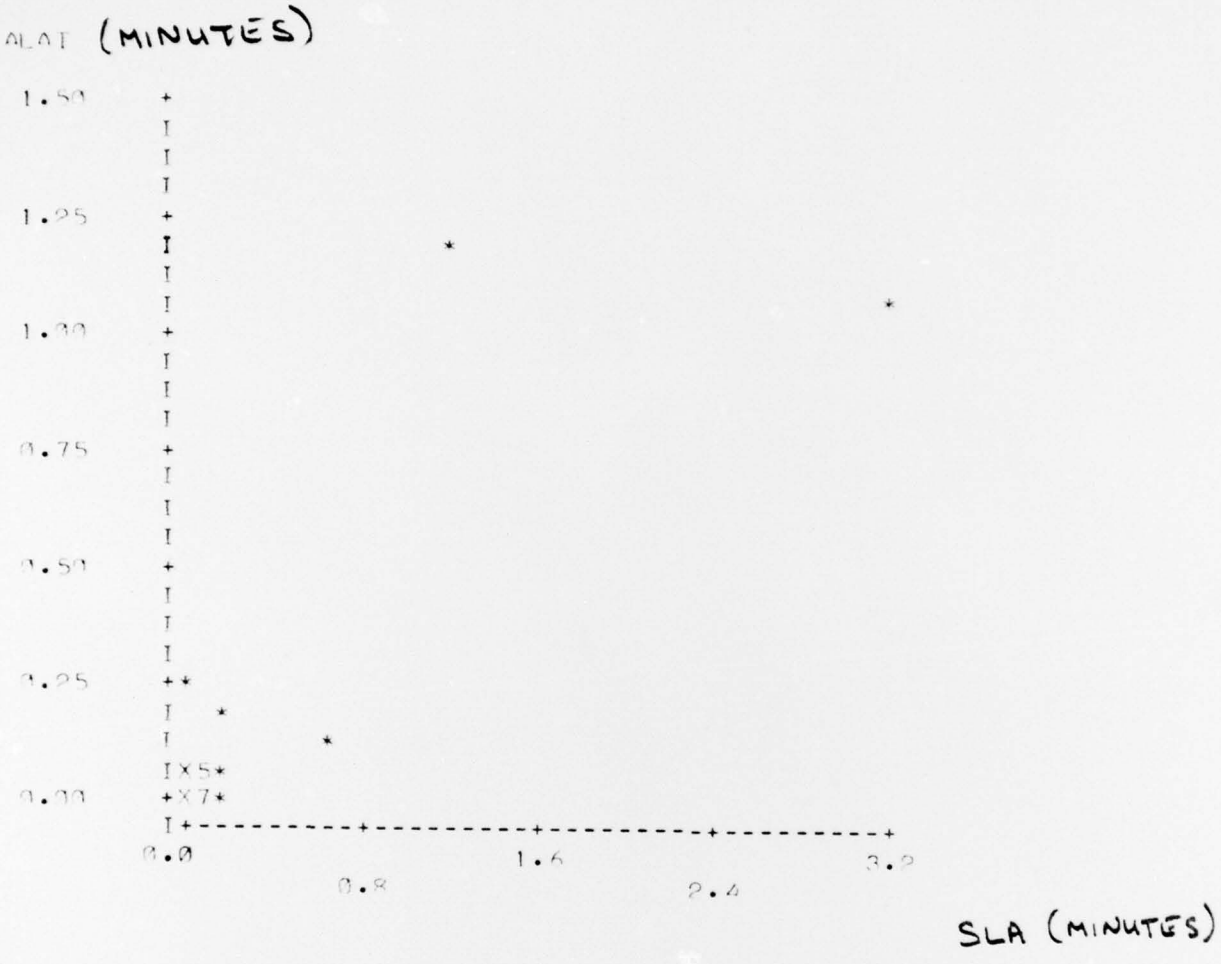
NOTE: * IS ONE POINT
1>9 INDICATES THE NUMBER OF MEASUREMENTS AT THAT POINT
X INDICATES TEN OR MORE MEASUREMENTS AT THAT POINT

PARTITION FIX.NOUPDATE

ALAT (MINUTES)



PARTITION VNFIX



ALON (MINUTES)

SLO (MINUTES)

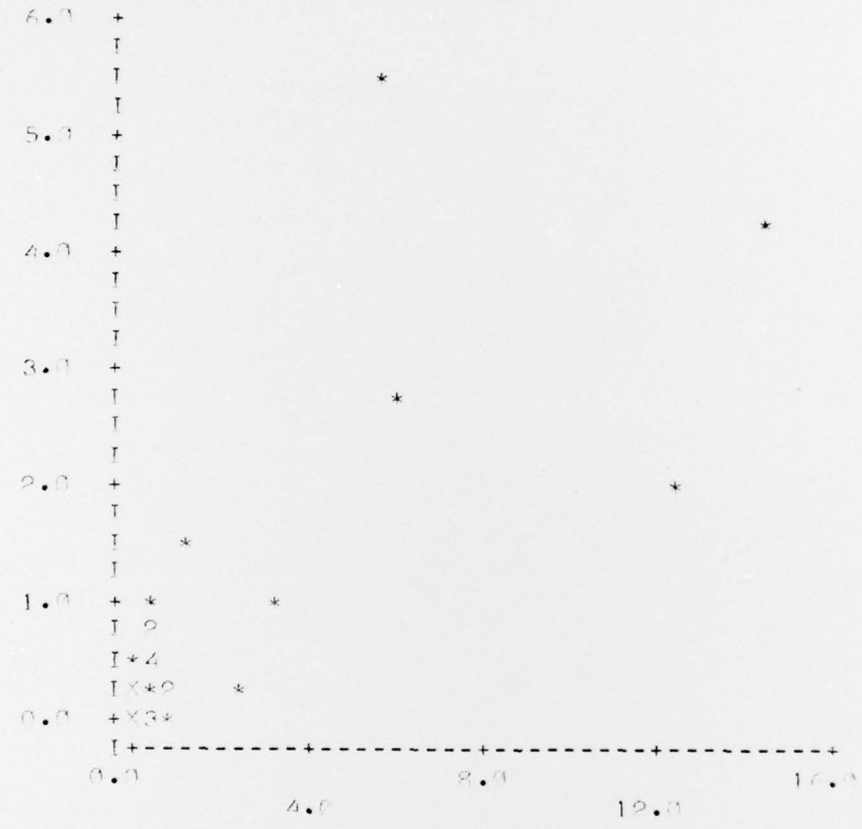
PARTITION FIX.NOUPDATE

ALON (MINUTES)

SLON (MINUTES)

PARTITION UNFIX

ALON (MINUTES)



SLO (MINUTES)

APPENDIX O: OUTPUT FROM STEPWISE REGRESSION PROGRAM TO TEST

MEASURED AND EQUIPMENT CALCULATED POSITION ERRORS

ABSOLUTE LATITUDE ERRORS

PARTITION FIX. UPDATE

EQUATION

ALAT = .02254 + .45623*SLA

R-SQUARED = .04086

PROCEDURE SUMMARY

STEP	VARIABLE ENTERED	VARIABLE REMOVED	VALUE	%	R-SQUARED CHANGE	CRITERION	F-RATIO ACTUAL
1	SLA		.0409			3.91	5.88

PROCEDURE ENDED WHEN
MAXIMUM F TO ENTER = .11 FOR RMS
FAILED TO MEET F ACCEPT = 3.91

PARTITION FIX. NOUPDATE

EQUATION

ALAT = -.01750 + 2.5168*SLA + .80966*RMS

R-SQUARED = .91730

PROCEDURE SUMMARY

STEP	VARIABLE ENTERED	VARIABLE REMOVED	VALUE	%	R-SQUARED CHANGE	CRITERION	F-RATIO ACTUAL
1	SLA		.9050			4.04	466.65
2	RMS		.9173		1.36	4.04	7.15

PROCEDURE ENDED WHEN
MAXIMUM F TO ENTER = .02 FOR SLO
FAILED TO MEET F ACCEPT = 4.05

PARTITION UNIFX

EQUATION
ALAT = .03245 + .39674*SLA

R-SQUARED = .73757

PROCEDURE SUMMARY

STEP	VARIABLE ENTERED	VARIABLE REMOVED	R-SQUARED VALUE	R-SQUARED % CHANGE	F-RATIO CRITERION	F-RATIO ACTUAL
1	SLA		.7376		3.92	334.46

PROCEDURE ENDED WHEN
MAXIMUM F TO ENTER = .63 FOR SLO

FAILED TO MEET F ACCEPT = 3.92

ABSOLUTE LONGITUDE ERROR

PARTITION FIX.UPDATE

PROCEDURE SUMMARY

NO INDEPENDENT VARIABLE QUALIFIED FOR ENTRY

PROCEDURE ENDED WHEN
MAXIMUM F TO ENTER = .09 for SLO
FAILED TO MEET F ACCEPT = 3.91

PARTITION FIX.NOUPDATE

EQUATION
ALON = -.01102 - 1.5203*SLA + 1.9331*SLO + 30.450*RMS

R-SQUARED = .94212

PROCEDURE SUMMARY

STEP	VARIABLE ENTERED	VARIABLE REMOVED	R-SQUARED VALUE	R-SQUARED % CHANGE	F-RATIO CRITERION	F-RATIO ACTUAL
1	RMS		.7997		4.04	195.62
2	SLO		.9365	17.11	4.04	103.42
3	SLA		.9421	.60	4.05	4.56

PROCEDURE ENDED WHEN
ALL ORGINAL VARIABLES ENTERED

PARTITION UNFIX

EQUATION

ALON = .07143 + 2.3665*ALAT + .21135*LONE + .89591*SLA

R-SQUARED = .53853

PROCEDURE SUMMARY

STEP	VARIABLE ENTERED	VARIABLE REMOVED	R-SQUARED VALUE	R-SQUARED % CHANGE	F-RATIO CRITERION	F-RATIO ACTUAL
1	ALAT		.5024		3.87	313.03
2	LONE		.5140	2.30	3.87	7.34
3	SLA		.5385	4.78	3.87	16.38

PROCEDURE ENDED WHEN

MAXIMUM F TO ENTER = 1.97 FOR LATE

FAILED TO MEET F ACCEPT = 3.87

APPENDIX P: Summary of offset frequency parameters v type of fix

PARTITION FIX.UPDATE

FREQ

CASES	140
MIN	-8.0078
MAX	.00000
MEAN	-4.3026
STD DEV	1.9804
STD ERR	.91308E-01

PARTITION FIX.NOUPDATE

FREQ

CASES	51
MIN	-19.687
MAX	-.24414
MEAN	-4.6196
STD DEV	2.7125
STD ERR	.37982

PARTITION UNFIX

FREQ

CASES	121
MIN	-34.648
MAX	38.650
MEAN	-4.2220
STD DEV	4.9265
STD ERR	.44782

APPENDIX Q: Frequency histograms v type of fix

PARTITION FIX.UPDATE

FREQ

-8.1	-7.3	2	+++
-7.3	-6.5	3	++++
-6.5	-5.7	8	+++++++++
-5.7	-4.9	23	++++++++++++++++++++++++
-4.9	-4.1	42	++
-4.1	-3.3	45	+++
-3.3	-2.5	14	++++++++++++++
-2.5	-1.7	1	++
-1.7	-.9	1	++
-.9	-.1	0	+
-.1	.7	1	++

PARTITION FIX.NOUPDATE

FREQ

-20.0	-17.0	1	++
-17.0	-14.0	0	+
-14.0	-11.0	0	+
-11.0	-8.0	2	+++
-8.0	-5.0	9	++++++++++
-5.0	-2.0	37	++
-2.0	1.0	2	+++

PARTITION VNFIX

FREQ

-35.0 - -27.0	1	+
-27.0 - -19.0	0	+
-19.0 - -11.0	0	+
-11.0 - -3.0	118	**********
-3.0 - 5.0	1	+
5.0 - 13.0	0	+
13.0 - 21.0	0	+
21.0 - 29.0	0	+
29.0 - 37.0	0	+
37.0 - 45.0	1	+

(* = 2.50)